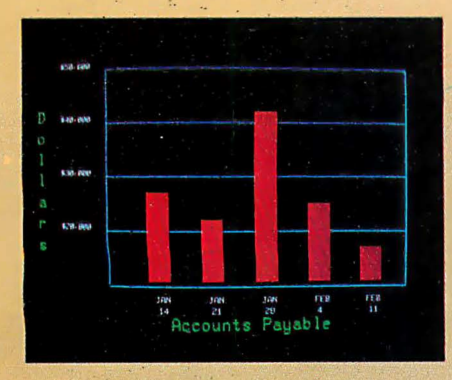
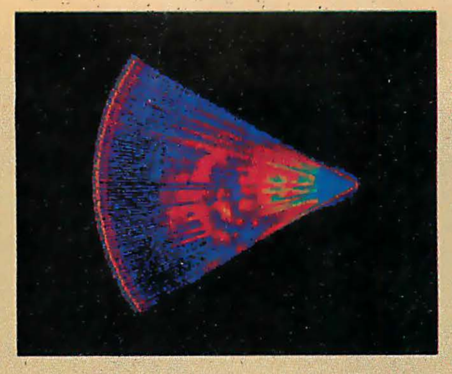


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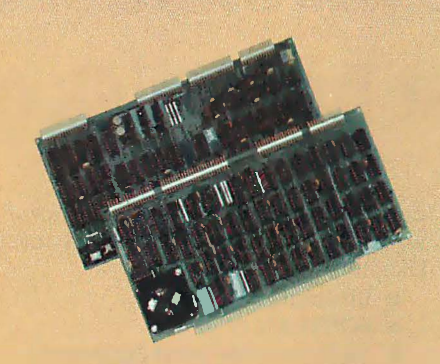
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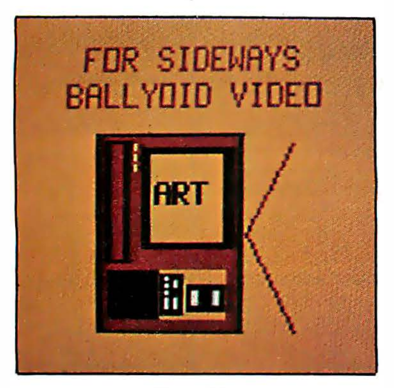


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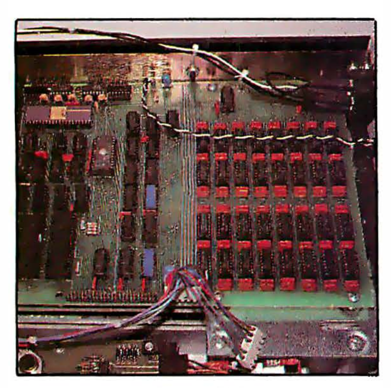
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In The Queue


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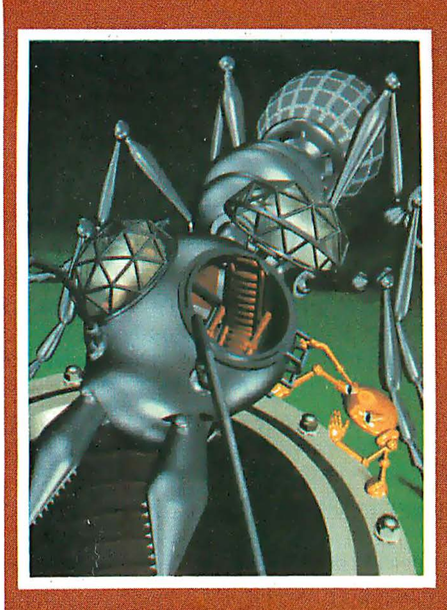

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Foreground

Background

Nucleus



In This Issue

The cover for this issue of BYTE is a still from a 90-minute computer-animated cartoon called *The Works*. The photo was provided by Dick Lundin and Lance Williams and is constructed from quadric surfaces and polygons, using texture-mapping and normal-perturbation techniques. The background was painted by Paul Xanter—programming credit also goes to Tom Duff and Duane Palyka. A trailer of *The Works* was shown at SIGGRAPH '80 (page 172), although the film itself may not be finished for another two years.

A number of the articles for this month's theme were solicited with the help of Jay Nickson and Ken Lodding; their editorial begins on page 6. Both are employed by DEC (Digital Equipment Corporation): Jay is the manager of the *human interface* program for simplifying man/machine communications, Ken is a senior software engineer whose long-term interests intermix art and computer graphics.

Publisher's Note

As most readers will have observed, the September Fifth anniversary issue marked the beginning of a new phase for BYTE. The jump from a 300-page to a 400-page issue means a 33% increase in the material presented to our readers each month.

Because advertisements tend to be more visible than editorial content (especially in a technical journal), some readers may suspect that the larger issues mean merely more ads. But, in fact, the larger issues have approximately one third more editorial content. The new size does create design and manufacturing problems, however. The solution to these problems includes a redesign of the editorial pages of BYTE to make the editorial content easier to find and use. We expect the new format to be implemented early in 1981.

We are confident that the increased editorial content and new format will make BYTE even more of a bargain as well as a more useful tool for our readers. And that, after all, is what it's all about.

Virginia Londoner
Publisher

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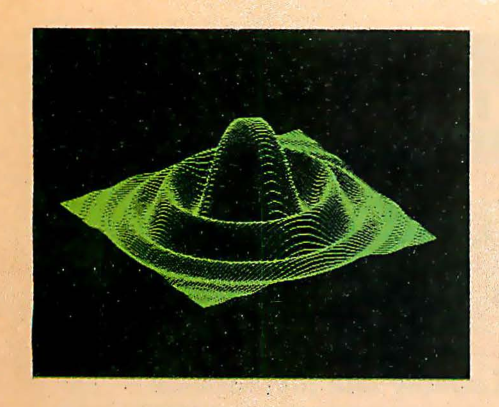
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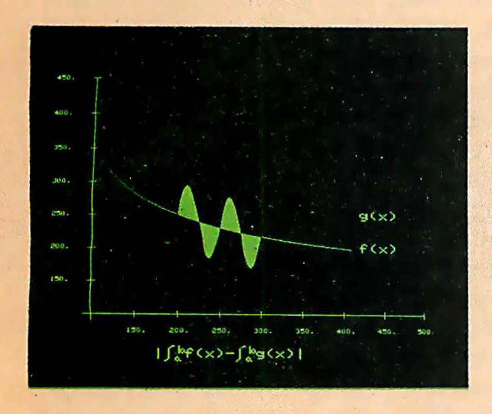
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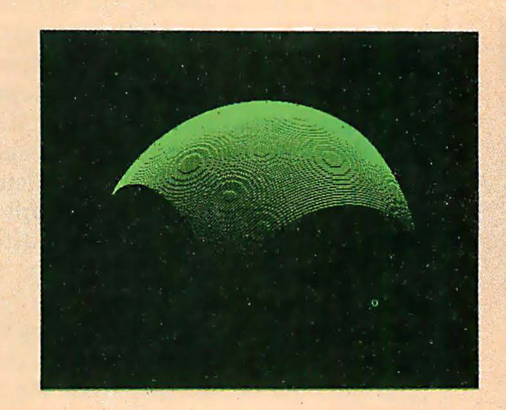
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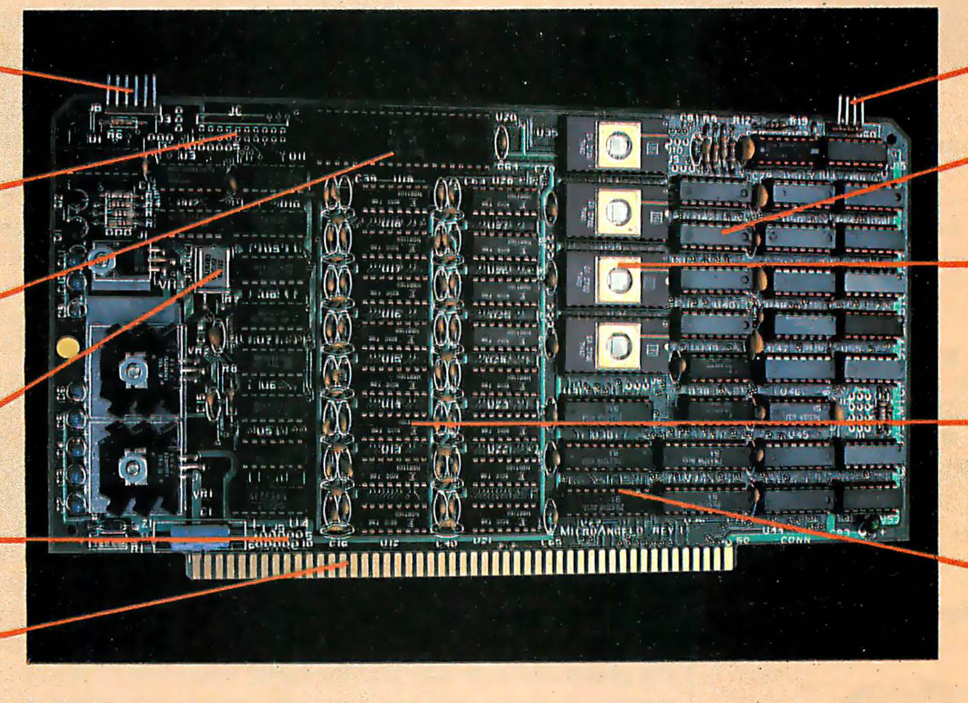
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Editorial

The World of Computer Graphics

Guest Editorial by Ken Lodding and Jay Nickson

Man is a visual animal. He surrounds himself with graphic images. Images are employed to convey information, to explain concepts, and to communicate feelings. The ability to draw is instinctive. It materializes in infants soon after the start of verbal development, perhaps to complement the slowly developing verbal skills. Although the ability to draw tends not to become as fully developed as verbal skills, images continue to provide much of the adult human communications ability. Pictures are a primary information-carrying channel: the histogram accompanying a financial article, the plot of a mathematical function, and the illustrations in BYTE are but a few examples.

The importance of graphics for conveying information arises from the nature of man's visual system. The eye provides an extremely high-bandwidth information channel for transferring the data to be processed by the brain's optic center. The importance of this channel can be seen from the redundancy built into the system and from the distribution of optic nerve fibers in the brain. It is believed that no less than six different brain sites are directly serviced by connecting optic nerve fibers. (See reference 4.) The fundamental importance of visual information is reflected in the old adage, "seeing is believing," and in the observation that *understand* is one of the synonyms of the word *see*. Text fails to use our native abilities to comprehend information fully because it presents data in a linear, sequential fashion. Contrast this with graphical images, which can be processed in a single viewing—a phenomenon called *preattentive perception*. (See reference 6.)

The computer has become a primary source or conveyor of information, yet the main interface between man and machine has remained the serially oriented text display. The net result is that, as the volume of data available to be presented increases, the user's communication channel becomes swamped with an avalanche of text output. The volume of this avalanche far too often restricts the comprehension of the information. The information is obscured as effectively as if it had been encrypted. The spectacle of the computer user literally buried under reams of printed output has ceased to be an amusing cartoon and has become a nightmare for too many. To cope with the flood of information, the computer user is turning to graphics.

The information-transfer rate of a graph can be many orders of magnitude greater than an equivalent text presentation. Conceptually, a graph has greater information density than a table. Compare the plot of a sine curve with a table of sine values. Each value within the table corresponds to a specific point on the graph. However, the plot displays a far greater number of points than could the most extended table. A high information-transfer rate results from the greater data density and the faster operation of the human mind and visual system. Patterns, periodic functions, trends, and comparisons can often be obtained "by inspection" of a graph, while understanding a tabular display requires much more time and effort. This is not, however, accomplished without a cost. The only penalty paid for speed is the loss of precision: a graph cannot be read to the same number of significant digits as can be obtained from a table. This loss of precision is not a problem, as the specific data value of interest can be extracted from the function or table of data used to generate the plot initially.

About the Authors

Ken Lodding and Jay Nickson are employed by the Digital Equipment Corporation in Merrimack, New Hampshire.

In addition to presenting data in a rapid, meaningful fashion, an important benefit of computer graphics is the ability to present images realistically. Plotting a topological surface, modeling DNA, creating an architectural rendering, and simulating a pilot's view from the cockpit of an aircraft are all enhanced by presenting the image in a manner which gives the viewer a sense that the picture is not an illusion. To achieve greater realism, a prime factor is to provide the illusion of depth. Perspective, hidden-line removal, shading, and highlighting all provide depth cues to the viewer. This month's computer-generated cover by Lance Williams of the New York Institute of Technology clearly illustrates the current state of the art as applied to an artistic endeavor. The same techniques are available and can be employed when graphically representing numeric data.

Three-Dimensional Graphics

To provide the illusion of depth, a three-dimensional model can be defined. Establishing the viewer's geometric relationship to the model and following the rules of perspective, the model image is mathematically projected onto a two-dimensional viewing plane. Although providing good visual depth cues (eg: parallel lines appearing to meet at a point), there is no real illusion of depth; in other words, the model image is still "flat." To correct this, the phenomenon of *stereopsis* (from the Greek, meaning "solid sight") can be employed. You may be familiar with the 1847 Brewster stereoscope. Here, the approach taken to give the illusion of depth was to photograph the same scene twice, having moved the camera about 6 cm sideways between photos. The two images could then be viewed through a stereoscope that utilized a prism and lens system to alter the image paths to the eye, so that the two views seemed to originate from a common point. (The old-fashioned stereopticon and the modern View-Master are variations on this theme.) The observer's visual system fused the two images, giving the illusion of a three-dimensional image.

Various computer-graphic techniques using the same principles have been developed. A common technique is to employ glasses with electro-optic shutter eyepieces to provide the image separation. With the electro-optic glasses, the *cyclopic* video display presents left- and right-perspective images in alternate frames, which are then synchronized with the electro-optic shutters. The left eye is presented with the left stereograph, while the right eye's view is blanked by the optical shutter; the image and shutter swap for the right eye. The viewer's internal visual system fuses the image to give the appearance of depth. For an example of this, see "The Future of Computer Graphics," page 22.

A different approach to providing left and right images to the visual system uses color to separate the images. Using a device called an *anaglyph*, the left view is presented in one color, and the right in a different color. Color filters control which eye sees what view. A program for generating and viewing anaglyphs is presented in the article "Three-Dimensional Graphics for the Apple II." (See page 148.) While the traditional colors employed are red and green, any two colors and corresponding filters could be used, because the illusion is based on the separation of the images, and has nothing to do with the particular colors. The phenomenon is as apparent to a

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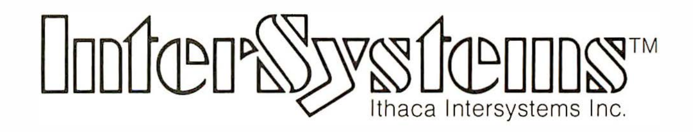
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Micros for bigger ideas.

color-blind person as it is to a viewer with normal color vision. For those interested in further information, the book *Seeing* is an excellent reference on vision in general and stereopsis in particular. (See reference 4.)

A more recent and unique approach to presenting three-dimensional images is SpaceGraph, developed by Dr Larry Sher. His technique uses a vibrating mirror and a video display. The technique is to generate on the display two-dimensional "slices" of the three-dimensional object to be viewed. The slices are rapidly generated in synchronization with the dynamic motion of the mirror, the front slice being generated when the mirror is extended toward the viewer, the back slice when the mirror is concaved away from the viewer, and the intermediate slices as appropriate for the travel of the mirror between these extremes. The rapid sequence of images is fused by the viewer's visual system to give the illusion of a "space filling" object. (See reference 7.)

Those adventuresome souls who find three-dimensions insufficient for their purposes can use computer graphics as an aid for visualizing objects which, theoretically, exist in four or more dimensions. If you are interested in this area, *Hypergraphics* is a good introduction to the subject. (See reference 3.) The book includes hyperstereograms of such objects as hypercubes or tesseracts, hypercones, and other denizens of higher dimensions.

Animation is another technique that can assist in user comprehension of data. Often we are dealing with information gathered at discrete intervals over a period of time. Here, the problem of analyzing data is one of understanding what is occurring to the data elements over some length of time. Animation provides a looking glass into the time domain. Flowing, three-dimensional images can represent anything from an economic world model to a bridge under stress.

Hidden Benefits

There are times when animation provides the viewer with unexpected information—information which, in retrospect, was present but not readily discernible by any other method of examination. An interesting example of this situation involves the simulation of an internal combustion engine. The simulation, performed at a research laboratory, wrote out data in the conventional manner: stacks of numbers. At the same laboratory, some time after the engine simulation had been completed and used for experiments, a different group of researchers developed a computer-animation system. The engine simulation was selected as a good demonstration of the new graphics software, and a computer-generated film was produced. During the screening of the film it was noticed that small rectangular elements, used to represent idealized gas packets, displayed a strange, unexpected oscillation at their endpoints. Review of the animation software provided no explanation for this erratic behavior. Close examination of output from the original simulation revealed that the oscillations were indeed present. This fact had not been previously noticed because the information had been obscured by a combination of the tremendous amount of data, the smallness of the oscillation, and the extended period over which it occurred. What had in fact been found were acoustical-wave phenomena occurring within the cylinder of the engine, which could potentially be used for the development of more efficient engines. The events went unnoticed until a computer-generated movie was constructed.

In the 30 years since its beginnings, computer-generated graphics has grown steadily, but not spectacularly. Previously the costs of both the display and the computer resources needed to support graphic displays have limited the impact. Rapidly falling memory prices and television technology have renewed the interest in computer graphics. The combination of a television raster display and a memory-intensive, bit-mapped architecture makes possible a graphic system capable of providing full-color, dynamic images with previously unheard of realism and economy. "Micrograph, Part 1: Developing an Instruction Set for a Raster-Scan Display," describes the design and construction of a color-display processor that costs approximately $250 to build. (See page 64.) This is possible only because of the plummeting cost of hardware. This is a cost reduction of three orders of magnitude in 15 years, with color added for free!

Graphics Software

The advent of inexpensive graphics hardware has, not unexpectedly, spurred the development of graphics software. The traditional approach for supporting graphics has been to provide a collection of subroutines that perform the graphic-display functions. These subroutines are called from languages whose orientation is toward the manipulation of text and numerical data. This approach is fine if you only want to accumulate data and make a

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The man, the wi

ng and the Apple.

If you could talk to Orville Wright, he'd tell you the problems he faced as a turn-of-the-century engineer. You could tell him all about the technological solutions available to today's engineer and scientist... particularly a 20th century phenomenon that tests assumptions and defines models before a project gets off the ground. The Apple personal computer.

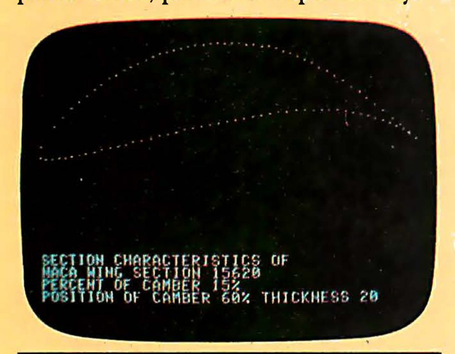
Computation, calculation, analysis...the power to pilot your projects.

With a highly-integrated system from the extensive Apple personal computer family, Orville and brother Wilbur would have increased their productivity. Perhaps even launched the Kitty Hawk Flyer well before 1903.

An Apple in their hangar would have freed them from the time and tedium of crunching numbers by hand.

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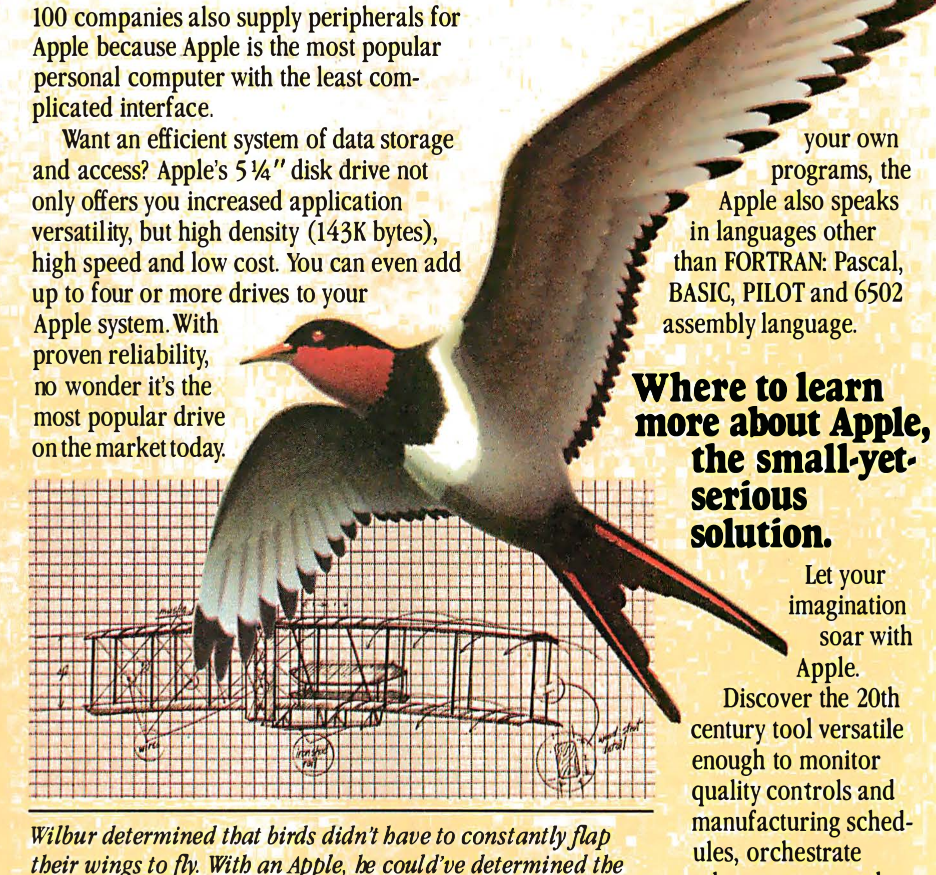


Apple's existing software library includes a program that plots the shape of an airfoil, given its parameters.

that's unparalleled for analyzing alternative paths of design and modeling a wide variety of physical processes.

Want more memory? Depending on your choice of system, Apple has memory expandable to 64K bytes or 128K bytes. Prefer wide displays? Choose 40 or 80 characters. Need to control instruments in the lab? Get on the IEEE 488 bus. Over 100 companies also supply peripherals for Apple because Apple is the most popular personal computer with the least complicated interface.

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Wilbur determined that birds didn't have to constantly flap their wings to fly. With an Apple, he could've determined the fixed-wing design of the Kitty Hawk Flyer much faster.

FORTRAN that helped to design a 20th century flying machine.

Fluent in the same language that helped to design the 747, Apple FORTRAN lets you tackle differential equations at the touch of a key. And since more than 170 companies also offer software for the Apple family, you can have one of the most impressive program libraries ever...including vast subroutine libraries for math, science, engineering and statistics. When you write your own programs, the Apple also speaks in languages other than FORTRAN: Pascal, BASIC, PILOT and 6502 assembly language.

Where to learn more about Apple, the small-yet-serious solution.

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picture from it. The subroutine approach excludes the possibility of treating graphical objects as variables within the language, or using them within statements and expressions. Some research work has been done which includes the concept of graphical objects and operators within a language structure. To date, there have been a number of different approaches to the problem of handling graphical objects. Deeply intertwined in the problem is our fundamental lack of understanding of how to provide graphics support. Viewed from the perspective of a language, what fundamental primitives must be provided? What are the appropriate data types? How are expressions constructed? What operators need to be provided? The list of unknowns goes on and on. "Language Control Structures for Easy Electronic Visualization," by Dr Tom DeFanti, addresses this area. (See page 90.) Some examples of other, experimental, graphics languages are given in references 2 and 5. SHAZAM (Smalltalk's sHaded imAge Zippy Animated Moviemaker) is an interesting animated-movie language written in Smalltalk. (See reference 1.) In no way does this list exhaust the progress that has been made in graphics languages, but rather it reflects a small sampling of recent work.

All the aspects of graphics we have discussed allow us to construct windows into universes, real or imaginary. Computer graphics is exciting because with this tool we can witness the unraveling of a DNA molecule, or the collision of galaxies. We can watch the structure of the universe as it expands from the moment of the theoretical big bang, or, reversing entropy, see it collapse into the primordial particle. We can plot a mathematical function, view an economic trend, or travel faster than light to where robotic insects populate metallic worlds. Best of all, we can make it all seem real, because we can see it! ■

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Articles Policy

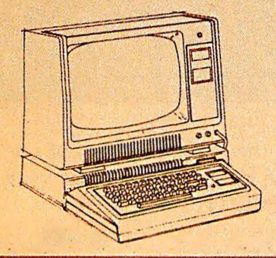
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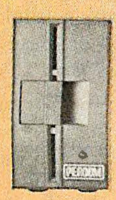
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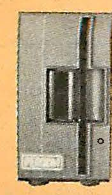
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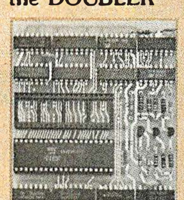
TFD-100 drives are "flippy" drives. You store twice the data per minidiskette by using both sides of the disk. TFD-100 drives store 180 Kbytes (double-density) or 102 Kbytes (single-density) **per side.** Under double-density operation, you can store a 70-page document on one minidiskette.

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Moore Praise Comes FORTH

If FORTH is trickery, give me more trickery.

In my view, FORTH is a common-sense approach to programming. Granted, there are also bits of pure genius thrown in.

It makes sense to put all the routines used by the operating system, compiler, parser, editor, etc, in one dictionary conveniently accessible to the user at all times. That is, if they will fit. One of the bits of genius of FORTH is that they do indeed fit with room to spare for user-defined routines. The result is instant liberation from the "systems man" who tries but can't please everyone. It is your computer, and with FORTH you have access to everything on it.

It makes sense to use a stack to pass parameters between routines and to separate this stack from the return-address stack. You end up with a language that is designed to compute rather than to be read. Every step in FORTH is directed toward computing a result. FORTH is a sequence of commands rather than statements as found in BASIC or Pascal. The functions of computing and documentation are separated. Hence I strongly disagree with Gregg Williams' advice (see August 1980 BYTE, page 130) that the user should introduce intermediate variables to improve readability. I concur with his objective, but I would encourage their use only in the commentary where they belong. There is no point to introducing unnecessary variables in the computing process. In the commentary, intermediate variables can and should be used very effectively to help describe the computations that are occurring on the stack without interfering with the process.

While FORTH takes away the expository statement, it does give back an important documenting feature, namely relative ease in preparing precise common-language definitions of each routine. All FORTH routines have a describable goal, and most of the action takes place on the stack. Hence FORTH routines tend to be simpler to describe. I have never seen a glossary for a language or operating system that comes even close to the completeness and conciseness of the fig-FORTH glossary supplied by the FORTH Interest Group. It is a gem, a complete English-language description of FORTH. Every routine on the computer is concisely defined in English.

You have to have faith that taking the sacred function of documenting out of the language and turning it over to the user to do as he sees fit will work. After a while, you begin to wonder if Milton Friedman didn't write FORTH for his television series *Free to Choose.*

Finally, it makes sense to give the programmer a shot at controlling the compiler, especially when the compiler has access to all the routines of the system. C H Moore has shown with FORTH that compilers do not have to be large inflexible systems which try to take into account every eventuality and really can't do it. The result of this bit of FORTH trickery is a powerful compiler so tiny that it can be made interactive and used on line with no batch processing, linking loader, or other monstrosity which we are accustomed to associate with a compiler.

How small (or big) is tiny? The fig-FORTH system supplied by the FORTH Interest Group for the 6502 contains 220 primitive routines (not including the Editor or Assembler) that occupy a total of 6221 bytes. By my count, 34 of these routines are compiler functions, and they occupy a total of 982 bytes. My guess is that this is an order of magnitude smaller than other compilers of comparable power. That is trickery.

If there ever is a contest for the all-time ingenious software development, I would like to nominate C H Moore's best, the { ;CODE } routine and/or its logical extension
{ <BUILDS ... DOES> }.

Edgar H Fey Jr
Edgar H Fey Jewelers Inc
1156 Fox Valley Ctr
Aurora IL 60505

Flash: Magic Exists!

I was delighted to see an issue of BYTE devoted to FORTH. As a user of and tinkerer with STOIC for 5 years, I heartily agree with the various authors' ravings about the extensibility, flexibility, and increase in productivity provided by FORTH. I was, however, amused at the many ways in which postfix (reverse-Polish) notation was rational-

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ized as being a better or more efficient way to do things even though it renders programs "write only" or at best difficult to read.

Since maintainability of programs becomes even more critical when productivity is increased tenfold or more, I feel that the requirement of postfix notation by FORTH is a serious shortcoming. There is nothing mystical about postfix notation; all compilers and interpreters must eventually reach this form because that is the order in which the computer must carry out its operations.

Over the past two years Jeff Morris and I have added various superstructures onto FORTH (one per application) that attempted to combine the better features of Pascal (eg: record structures, algebraic notation) with the power and flexibility of FORTH. The outcome of all of these experiments was a conceptual breakthrough which resulted in the invention of Magic. Magic has all the advantages of FORTH, plus, Magic programs are readable (thus maintainable).

For example, the FORTH (or Magic) statement:

```
B@ C@ + A@ * A!
```

can also be written in Magic as:

```
A: = A*(B + C)
```

and in fact compiles in three fewer words (since the @s are not needed), and the FORTH (or Magic) statement:

```
A@ B@ = IF
```

can also be written in Magic as:

```
IF(A.EQ.B)
```

Magic is a major enhancement to the basic compilation structure of FORTH (a metaFORTH), not simply an add-on superstructure. Magic programs typically compile more slowly (due to the increased complexity of the compiler) but require less memory and run faster than equivalent FORTH programs.

The concept of metaFORTH is discussed briefly in the article by Kim Harris. (See "FORTH Extensibility: or How to Write a Compiler in Twenty-five Words or Less," August 1980 BYTE, page 164.) This is the direction of the future and will be the source of some super-powerful programming tools in the next decade. Magic is a first step in that direction.

I hope and expect that new metaFORTH languages such as Magic will be developed so that FORTH users can have their cake and eat it too. The time has come to stop justifying the unreadability of postfix notation.

Arnold Epstein PhD
Director, Software Development
Octek Inc
7 Corporate Pl
S Bedford St
Burlington MA 01803

Needs Tektronix Secrets

Can a BYTE reader help me? I have a Tektronix 4051 computer which came with a BASIC interpreter. Some of my programs must run faster, and I would like to rewrite them in machine code. Tektronix states that machine code is unsupported on the 4051 and suggests spending another $10,500 for a faster Model 4052. Someone somewhere is programming the 4051 in machine code, as "Space Tag" on the demonstration tape is in machine code and runs incredibly faster than ordinary BASIC programs.

Richard Daily
800 Charlesgate Dr
St Louis MO 63122

Information Please

I recently acquired a Video Brain home computer built by A Umtech Company. The serial number is 003087 and the model number is 101A. It was built in either Santa Clara or Sunnyvale,

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California. I understand it has a Fairchild F-8 8-bit microprocessor. It has 1 K bytes of programmable memory and 4 K bytes of read-only memory.

What I am looking for are cartridge programs, which have a 45-terminal bus, the expander sets, or anything that would be interchangeable. Also, any information or leads would be gratefully appreciated by me and my friends.

Richard L Rowland
7072 Kenwood
Las Vegas NV 89117

An Overlooked FORTH Vendor

The staff at Datricon Corporation was both delighted and disappointed with the August 1980 BYTE. Our delight stems from the extensive coverage of the language FORTH and Charles H Moore's interesting article, "The Evolution of FORTH, an Unusual Language," page 76.

However, we were disappointed with BYTE's failure to mention Datricon's ACS 12-PRO or Datricon's 4 K D-FORTH. Datricon's implementation of FORTH resides in 4 K bytes of EPROM (erasable programmable read-only memory), produces code that can be placed into ROM (read-only memory), and provides for interrupt handling and the automatic setting of the data-transfer rate. Our ACS 12-PRO, with D-FORTH and the STD BUS interface, is a very powerful 6800-based single-board computer. A development package is also available for generating application EPROMs.

Jed W Heald, President
Datricon Corporation
7911 NE 33rd Dr
Suite 200
Portland OR 97211

*We at BYTE were surprised to find additional FORTH vendors advertising in our August 1980 issue. Other vendors include Rockwell International (for the AIM microcomputer, see page 67 of the August 1980 BYTE), Kenyon Microsystems (for 6809 systems, see page 104 of the same issue), Sirius Systems (for the Radio Shack TRS-80, see page 171), Quality Software (for the Exidy Sorcerer, see page 208), Eric Rehnke (for the KIM, SYM, and AIM computers, see page 290), the Software Farm (for the TRS-80, see page 292), and Professional Management Services (for the Alpha Micro, see page 294). FORTH vendors not listed in the August 1980 BYTE are invited to submit a two-paragraph product release, which will be published in a future BYTE "What's New?" column....*GW

FORTH Is Better Than LISP, He Cs

Unlike BYTE's earlier issue on LISP, the August issue on FORTH did an excellent job in making this intriguing language readily understood. The articles did not come right out and say that FORTH is so machine-efficient due to the user preprocessing his logic into postfix notation, but most readers should realize this.

Although I can tolerate that sort of notation for a desk calculator, it is unbearable for computer data processing. Although the C language is philosophically different, it is a threaded language which is much preferable.

Dick Sims
185 Freeman St, Apt 951
Brookline MA 02146

Check Out a Computer

I always look forward to the new issue of BYTE and was especially eager to read the July 1980, Computers and Education issue. Arthur Luehrmann's article, "Computer Illiteracy—A National Crisis and a Solution for It," page 88, struck home on a point with which I wholeheartedly agree: "this country's general public is woefully ill-prepared to live and work in the Age of Information."

I was, however, disturbed by the fact that the role of public libraries was never mentioned. Public libraries are in a unique position to help solve the problem: they serve people of all ages, regardless of educational background; they are generally open more hours than schools; they are, perhaps more than any other institution, vitally interested in an information-aware public; they specialize in providing access to information, and they are free.

Many public libraries have microcomputers available for public use and provide a complement of interactive programs for individuals to learn with. Libraries that have done this report extensive and enthusiastic use of the equipment.

It's a sorry fact that most people have just never had the opportunity to even see a computer system. Until the opportunity to see, touch, and use computers is afforded, computers will remain shrouded in mystery for the vast majority of people of all ages. The public library is one of the best hopes we have to alleviate this problem.

Carlton A Sears
Adult Services Coordinator
Asheville-Buncombe Library System
67 Haywood St
Asheville NC 28801

Letters continued on page 122

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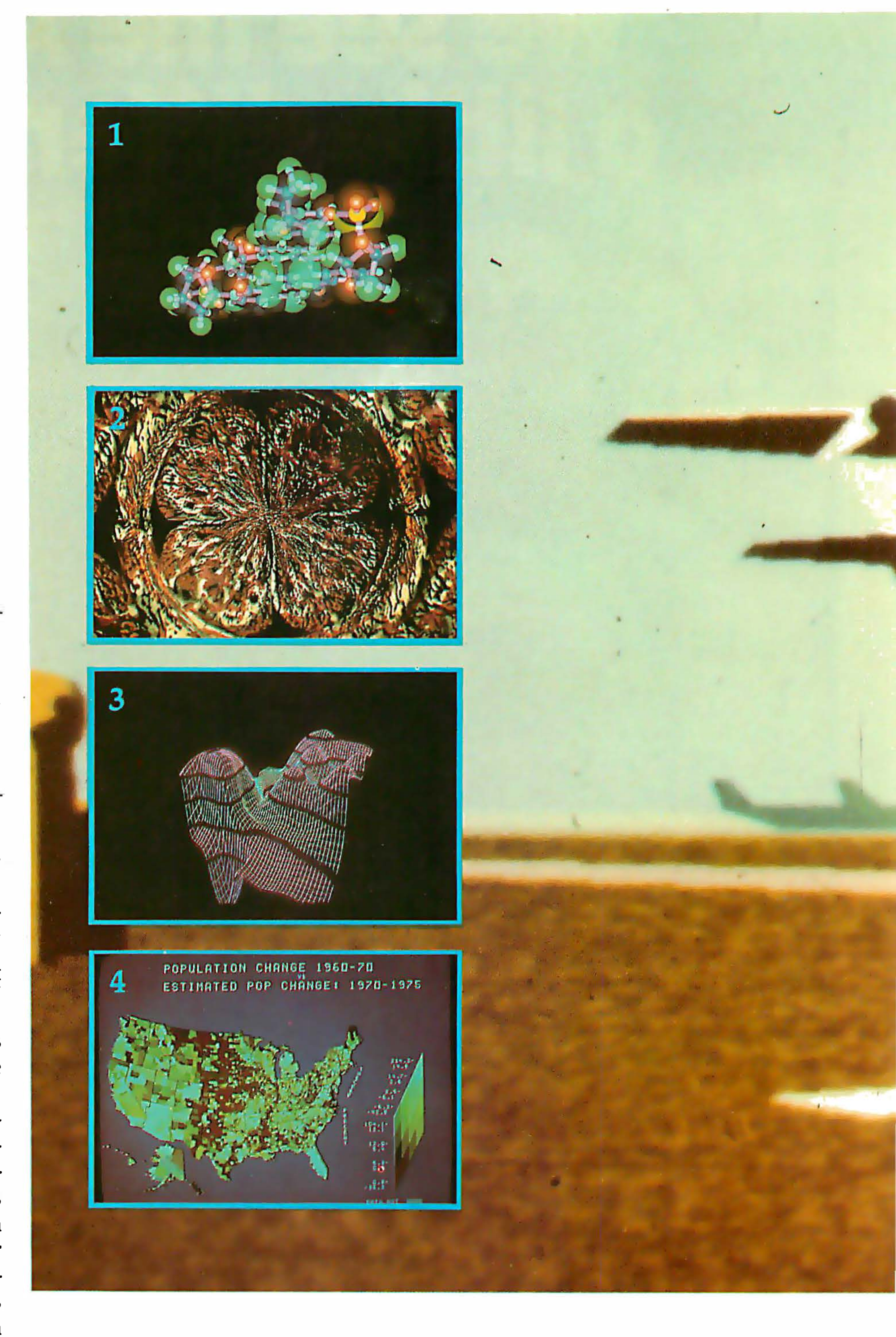
To find out how much computer your Apple II can be, see things our way. Because for serious users with serious uses for the Apple, we've got the tools.



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The Future of Computer Graphics

Bruce Eric Brown
and
Stephen Levine
Lawrence Livermore National Laboratory
University of California
POB 808
Livermore CA 94550



Predicting the future can place one in a very precarious position. Although technology is moving forward at such a pace that it is almost impossible to look a long way down the road, we *do* have a good idea of what the *near-future* trends will be. So here I will discuss where the trends in computer-generated graphics are headed.

Computer graphics is the fastest-growing segment of the computer industry. Although many existing computers already have graphics capabilities, the future is even brighter. Since personal computer users will make up the largest percentage of the computer graphics market, the standard color television receiver will be the most common display device. Research is continually going on in video-generation techniques, and we can expect the quality of video images to improve dramatically.

Also on the horizon is the use of networks. Best of all, the price of graphics systems should continue to fall, and as they do, the number of applications will increase drastically.

Editor's note:
*It was only 5 years ago when the first annual computer graphics show was held. The Philadelphia show was sponsored by SIGGRAPH (the Association for Computing Machinery's Special Interest Group on Computer Graphics). At that time, the show attracted ten vendors and a few hundred visitors. SIGGRAPH-80, which was held this summer in Seattle, brought to that city over 100 vendors, about 6000 visitors, and filled twenty-four times the space of SIGGRAPH-75. So you can surmise how the the computer graphics field will continue to grow....*SM

Three Dimensions

This is an exciting time for experimentation with computer graphics. Looking into our crystal video display, we can see many changes coming within the next few years. True three-dimensional displays will become common. Researchers will finally be able to see their models in three dimensions without the need of special glasses, stereo pairs, or by viewing two-dimensional projections.

Already in existence are integral hologram displays made from computer-generated images. (An example is shown in photo 9.) The



Photo 1: *A computer-generated composite view of a DNA molecule using both ball-and-stick and space-filling models. Using keyboard control, the configuration of the model can be changed and it can be rotated in any direction. Such models are already assisting scientists in their research and will have an even bigger role in the coming years. Photo courtesy of Nelson Max, Lawrence Livermore National Laboratory.*
Photo 2: *Computer-generated art by Los Angeles artist David M. As you can see, computer graphics could revolutionize the world of art.*
Photo 3: *A perspective view of a two-dimensional array of numbers. Photo courtesy of Melvin L Prueitt, Los Alamos Scientific Laboratory.*
Photo 4: *Census data plotted to show population changes. This is an example of the type of material which could be available on a computer network with wide-band capabilities, such as cable television. Courtesy of Edward Zimmerman, White House.*
Photo 5: *A ground-level view of a computer-generated airport scene used in a real-time flight simulator. Photo courtesy of Marconi Radar Systems.*

holograms are made by photographing 1080 computer-generated images on 35mm film and transferring them to the hologram. In a few years it will be possible to generate these directly; we might even see a laser-driven, computer-controlled, holographic-image output device.

There are currently several methods in use for displaying three-dimensional television images, but the most promising uses an interlaced television picture. The even scan lines display an image for viewing with the right eye and the odd scan lines have an image for the left eye. The screen is viewed through a pair of glasses whose lenses are made with PLZT (lead lanthanum zirconate titanate) ceramic. Voltage pulses synchronized with the display of the odd and even fields darken the left and right lenses alternately. As a result, the viewer sees a true three-dimensional image. Photo 10 is a composite view of a display showing the images for both the left and right eyes.

Raster-Scan Displays

Low-priced memory will also change the look of computer graphics. Up to the present, the market has been dominated by storage tubes and calligraphic (ie: stroke-writing) displays; however, raster-scan displays can be refreshed from a frame buffer of semiconductor memory. Therefore, in the coming years, we can expect the graphic-terminal market to be dominated by raster-scan devices. The standard display will be a color television receiver connected as a mirco-processor-controlled intelligent terminal. The cost of some of these graphics terminals will be at or near the cost of a modern color television receiver.

Raster-scan color television will probably be the graphics standard for the following reasons:

- The US video standard is well established.
- It has a large industry supporting it.
- The cost of developing another standard is prohibitive.
- The great numbers of personal computer users will help determine the trend. Why buy a color output monitor when you already have one or several available at home?

Top-of-the-line video displays will include devices with 1000-line resolution (already available) as well as a number with 2000-line resolution. The cost of these will be significantly higher than that of a modern color television receiver.

On a raster-scan display, each dot on the screen is known as a picture element or pixel. Since each pixel is displayed 30 times a second, the image generator must either generate 30 Hz or store the pixel intensities in memory. Frame-buffer systems usually use dual-ported memory which both stores the image and refreshes the display.

To simplify things, let's assume a square picture with the standard 500 lines and each line containing 500 pixels. To display a completely black-and-white line image with no shades of gray we would need 250,000 (500 by 500) bits or 32 K bytes of memory. In order to display gray levels, the number of bits used for each pixel must be increased. To display color, we either divide the number of bits available among the three primary colors (red, green, and blue) or use a color map. A color map takes each pixel value stored and outputs the three intensities: the most common method is to use 1 byte input and 3 byte output. The number of colors which can be displayed is the product of the number of output intensities for each color. At a given time, only a subset, which is limited by the input values, can be displayed. If we use 8 bits in, 24 bits out, we can display any 256 colors of the 16,777,216 available.

In the near future we should be seeing 2000-line resolution systems with 24 bits per pixel (1 byte for each of the three primary colors and 12 bits per color in the map). 12 megabytes of memory would be needed for such a system. With memory prices expected to continue to fall, in about 5 years the major cost element of such a system would be the monitor and electronics.

Vector Displays

Although it appears that raster-scan displays will have the major share of the graphics market, line-drawing (ie: vector-display) systems will continue to grow, though at a slower rate. There are basically two types of line-drawing systems: the storage tube and the refresh calligraphic writer.

Storage tubes available today have higher resolution and greater image stability than most refresh systems. One disadvantage of the storage tube is the lack of selective erasure. In order to remove one line the entire screen must be erased and redrawn. With refresh displays the line is removed from the display list and the line is redrawn on the next refresh cycle.

Calligraphic displays can display about 20,000 three-dimensional vectors or 100,000 two-dimensional vectors at 30 Hz. In the next few years we can also expect a doubling of these capacities.

Raster-scan display buffers can also be used to display vector images and should begin to replace calligraphic displays as faster hardware becomes available. Many users will probably prefer the somewhat slower speed of the raster scan since they are able to display continuous-tone color images.

Photo 6 (above): *An example of the computer-generated graphics used to train space-shuttle pilots at the Johnson Space Center in Houston, Texas.*

Photo 7 (below): *The control panel for an experimental fusion reactor at Lawrence Livermore National Laboratory. Transparent touch panels mounted over the color video displays have eliminated most switches. To control the reactor, the operators need only to touch the screen over the desired control area shown on the screen. Photo courtesy of Glenn Spreckert.*



Input

One tool which should see much use in the future is a transparent touch panel mounted over the face of a video screen. As shown in photo 7, an automated nuclear-reactor control room is one of the many possible applications. (Note the lack of switches.)

Hard Copy

Currently, one of the major problems of graphic terminal users is how to satisfactorily get hard-copy output. The most common method is to use a camera to take a picture of the video screen. A device is also available which records the video output directly on film. Both of these methods leave much to be desired. The final solution may not necessarily come from the manufacturers of graphic terminals. The goal of copying machine companies is a dry method of putting a color image on a piece of paper (like the current, dry black-and-white-image method). At present, the device with the highest-quality color output is the film recorder. For raster output devices, the resolution of current recorders is 4000 by 4000 pixels, each with a range of 256 intensities. These devices use

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as many as seven filters and multiple passes are made on the film to create full-color images. Additive-color red, green, and blue filters or subtractive-color yellow, cyan, and magenta filters are used. In both systems, the seventh color is neutral for plotting black-and-white images. We can expect to see more of these recorders available in the near future, and some of the stripped-down models should be available at lower prices.



Photo 8: *A problem in hydrodynamics illustrated through the use of computer graphics. The photo is part of a series illustrating a steel rod impacting a steel plate. Color changes represent areas of varying stress. In the future, such graphics will be widely used in education. Photo courtesy of Lawrence Livermore National Laboratory.*

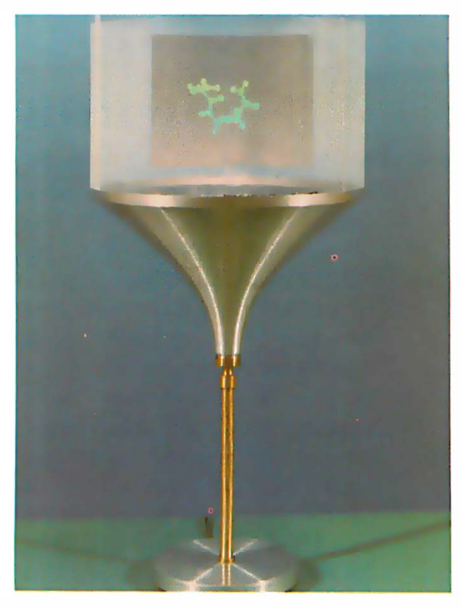


Photo 9: *Integral hologram of a molecule created by photographing 1080 computer-generated images on 35mm film and then transferring them to a hologram. In the future computers will be able to generate holograms directly. Photo courtesy of Donald L Vickers, Lawrence Livermore National Laboratory.*

Another group of devices which fit into this category of film output are COM (computer-output-on-microfilm) devices. Many of those currently available have graphic capability as well as variable intensity. At the present time, COM devices are mainly used for alphanumeric-fiche output. Currently only black-and-white machines are available, although color-fiche machines are expected to be produced in the future. The most important consideration is the need for high-quality, large-format color images. The resolution of current COMs is about 32,000 by 32,000 pixels. Although higher resolution is theoretically possible, such devices will not be produced until a need for them is demonstrated.

Laser recorders may soon capture a portion of the expanding graphics market. Since a laser beam has much more energy to deposit on film than a CRT (ie: video display) image, laser recorders will be much faster than existing methods. On a modern film recorder, one full-intensity pass at 4000 by 4000 pixels takes about 1 minute. To record the same amount of data, the laser requires 1 second or less. The energy of a laser beam is great enough that a split beam could record up to five copies at the same time.

A current weak link in laser systems is the deflection systems. Although solid-state methods are being developed, rotating mirrors are used today. Another drawback with any system that uses film is that unless users have their own processing facilities, film development takes at least 24 hours and sometimes much longer.

The Xerox 6500 color copier can be interfaced to a number of terminals for image-recording, or it can be connected to computers for direct output. Ink-jet plotters, printers with color ribbons, and flat bed-drum plotters with color pens are included in this class of output devices. Continued improvements in speed and color reproduction can be expected.

The brightest future is for the video disk. Today, these devices can hold 50 minutes (180,000 frames) of video per disk. Although the initial cost is high, the great number of frames available makes this device the ideal output and storage medium.

Computers — The Future

Although so far I've concentrated on graphics hardware, what about the future of the beast behind the display — the computer?

It seems likely that within a few years the home computer user will have a choice of several 32-bit virtual machines with at least a million words of expandable, central memory, and 100 million words of disk space. This type of system will be ideal for a color-frame buffer system.

Applications

Since pictures are a very efficient means of communication, the future applications of computer graphics are virtually unlimited. Photo 6 is a photograph of computer-generated graphics used to train space-shuttle pilots. Within the next few years, games and simulations with graphics of nearly the same quality will be available to the personal computer user. The PLZT glasses described earlier will be used to provide three-dimensional images for the would-be space-shuttle or 747 pilot. You can also expect the technology to be put to use in amusement parks. The Disneyland people have already used computer-generated graphics in some of their attractions and are continuing to develop them for future use.

Networks

There are a number of advantages to having your own, isolated personal computer, but connecting it to a network opens up a vast new world. Networks designed specifically for personal computer users, such as The Source, are already in existence. Unfortunately, the narrow bandwidth of conventional voice-grade telephone lines severely limits graphic capabilities.

One future possibility is the use of cable television for networks with graphic capabilities. Cable is increasingly available in all but the most rural areas and has wide bandwidth, portions of which are not used. Personal computer users could tap into this resource and use the extra bandwidth for local communication nets.

Another possibility is to have the

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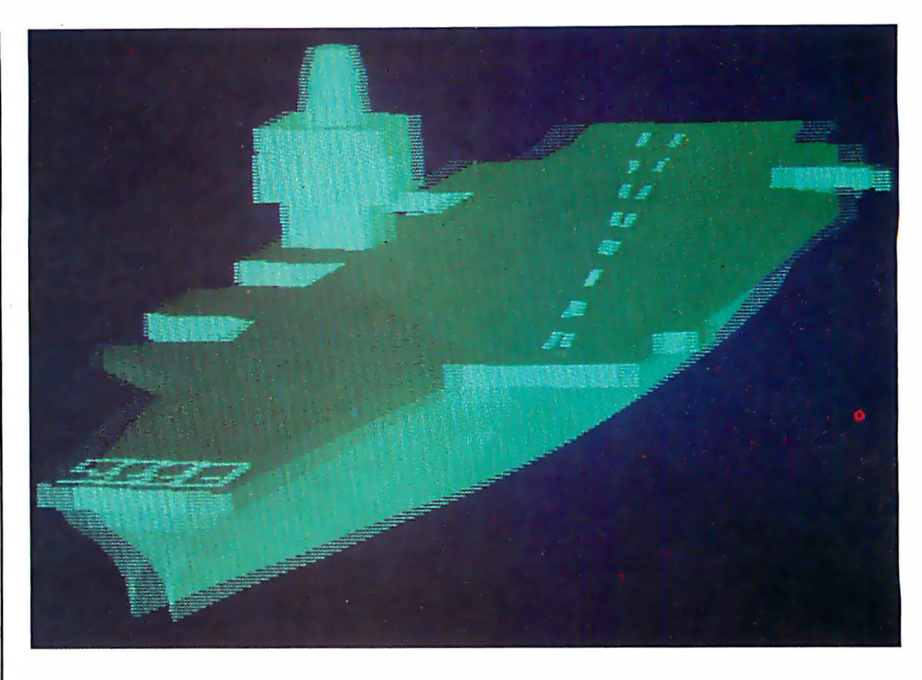


Photo 10: *Interlaced left-eye and right-eye view of a computer-generated image of an aircraft carrier. The image is viewed in three dimensions when the user wears glasses with lenses made of PLZT (lead lanthanum zirconate titanate) ceramic. The lenses by the right and left are darkened alternately by voltage pulses synchronized to the display. Photo courtesy of John A Roese and Larry E McCleary, the Naval Ocean Systems Center.*

cable-television company provide a main computer to control the network and act as a data base. The range of services which could be provided is virtually limitless. An example is shown in photo 4, where census data has been plotted to show population changes.

Exploring the Future

Computer graphics have exciting possibilities as an artistic medium. It's been said that computer-generated color graphics will revolutionize art in the same way that acrylics changed the world of artists who once worked with oil paints. Photo 2 shows computer-generated art by Los Angeles artist David M.

The simulators discussed earlier will also be widely used by filmmakers. Special effects, instead of being animated one frame at a time, could be programmed and filmed in real time. For instance, a director could ask for an airport scene on a clear day, as in photo 5. By changing a parameter, the same scene could be created on a foggy day.

The motion picture industry is in the forefront of developing and using sophisticated systems for computer-generated graphics. Increasingly higher levels of realism will be created in the future and the time-consuming tasks of creating special effects and editing will be performed using laser scanner/recorders and video disks. In terms of dollars, the movies will be one of the largest users of computer graphics for the near future.

Applications, as we've seen, are limited only by our present imaginations. Photo 1 shows a computer-generated composite view of a DNA (deoxyribonucleic acid) molecule using *both* ball-and-stick and space-filling models. Such displays will speed up the rate of research. The molecule model can be rotated, changed in configuration, and taken home for the scientist to use on his personal computer.

Classroom displays will greatly surpass the audio-visual methods commonly used today. Photo 8 shows a hydrodynamic problem with impact calculations displayed through color changes. A computer display of this sort could be created and updated in the midst of a lecture.

In the wide world of computer-graphic applications, we have only scratched the surface.■



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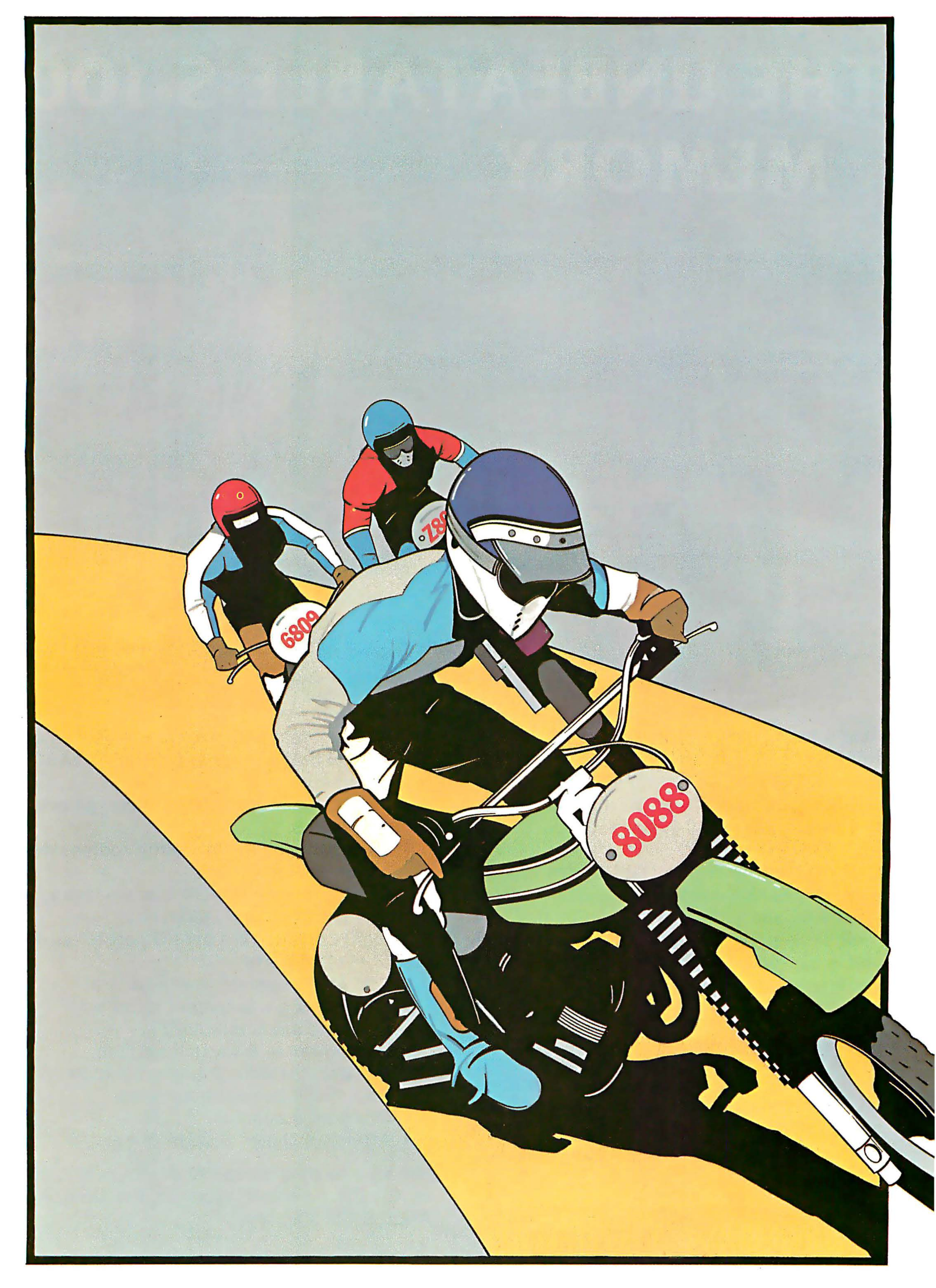
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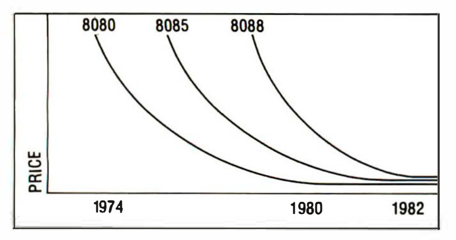
In price-performance races, the iAPX 88 is the one to beat. It's two times faster than the Z-80A and the 6809. And recent benchmark tests show that the iAPX 88, with its 8088 CPU, consistently outperforms its closest competitors in memory efficiency, ease of programming and throughput—by as much as 4 to 1. This is especially important in high-performance tasks such as block moves, character searches, word shifts, and 16-bit multiplies. All critical for applications like word processing, terminal control, scientific instrumentation and industrial control.

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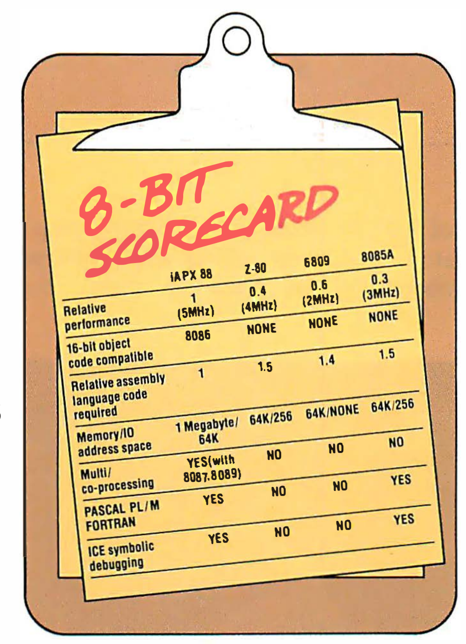


8-Bit Microprocessor Price Trends

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Relative assembly language code required	1	1.5	1.4	1.5
Memory/IO address space	1 Megabyte/ 64K	64K/256	64K/NONE	64K/256
Multi/ co-processing	YES(with 8087,8089)	NO	NO	NO
PASCAL PL/M FORTRAN	YES	NO	NO	YES
ICE symbolic debugging	YES	NO	NO	YES

the kind only Intel delivers today. Software that produces object code directly and gives you important extensions that allow you to fine-tune the software to your application.

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So if you want to outdistance the pack, choose the iAPX 88—available today from your local Intel distributor. To get your copy of benchmark results, contact your local Intel sales office or distributor. For more information write Intel Corporation, 3065 Bowers Avenue, Santa Clara, CA 95051. Or call (408) 987-8080.

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Home In on the Range!

An Ultrasonic Ranging System

Steve Ciarcia
POB 582
Glastonbury CT 06033

Each month I try to present a hardware project that is both interesting and relatively easy to build. Unfortunately, it's not as simple as picking a topic and quickly whipping up some circuit. More often than not, I have a number of potential topics and projects on the fire at the same time. Some are in limbo and just waiting for the right parts. Others are postponed when it turns out that the necessary hardware is something that could be better built by NASA (National Aeronautics and Space Administration) than by a computer hobbyist.

One topic that has always interested me is the concept of automatic ranging. I became involved with this idea when I wrote an article entitled "I've Got You In My Scanner," November 1978 BYTE, page 76. The original article was about an infrared sensor and parabolic reflector mounted to rotate on a stepper-motor shaft. With computer-controlled stepping, the result was something like the sweep of a radar antenna. The project was sensitive to infrared and visible light.

The scanner, parabolic-reflector, and stepper-motor combination could easily tell the direction of a light source to an angular resolution of 7.5°. It could make a 180° sweep, stop, and then follow the brightest object in its field of view. By recognizing the absence of known light sources (when the light path is blocked), it could even function as part of an intrusion alarm.

Diagrams and schematics of the Ultrasonic Ranging System Designer's Kit were provided through the courtesy of Polaroid Corporation.



Photo 1: *A computer-controlled, stepper-motor-driven infrared and ultrasonic ranging scanner. An infrared-sensitive photo Darlington transistor (GE L14F2) is mounted at the focus of a parabolic reflector, which is attached to the shaft of a stepper motor; the ultrasonic transducer is mounted above it.*

The infrared sensor and drive mechanism were described in a previous Circuit Cellar article, "I've Got You in My Scanner! A Computer Controlled Stepper Motor Light Scanner."

However, even though it could "see," the infrared scanner could not tell how far an object was in front of it, or detect the presence of a nonluminous body crossing its path. What I really wanted was a device that could provide the computer with range as well as direction. That's when I started hanging around the camera shop.

Polaroid to the Rescue

The automatic focusing system on the Polaroid SX-70 Sonar OneStep Land camera intrigued me. I had considered tearing a camera apart just to use the ranging unit for my scanner, but sanity prevailed and I went back to designing my own circuit. Somewhere between thoughts of "Who'd really build this thing anyway?" and "I hope everyone can find all these components," I started seeing ads from Polaroid offering just what I wanted, without the camera.

The solution came in the form of an Ultrasonic Ranging System Designer's Kit sold by Polaroid for $125. The kit contains a technical manual, two instrument-grade electrostatic ultrasonic transducers, a modified SX-70 ultrasonic circuit board, an experimental demonstrator display board, and two Polapulse 6 V batteries. With this unit I was able to enhance my original infrared-scanner

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design to include automatic range detection. The new scanner system incorporating the Polaroid unit is shown in photo 1. More on this later.

Polaroid Ultrasonic Ranging System

The Polaroid Ultrasonic Ranging System Designer's Kit costs $125 (This offer is good until December 31, 1980. Photo 2 shows the Designer's Kit as received.), and is available from:

Polaroid Corporation
Ultrasonic Ranging Marketing
Department 465 E
20 Ames St
Cambridge MA 02139
telephone (800) 225-1618

Two primary components compose the ranging unit. They are the electrostatic transducer (see photo 3) and the ultrasonic transceiver board (see photo 4). Together these components are capable of detecting the presence and distance of objects within a range of approximately 0.9 feet (0.3 meters) to 35 feet (10.6 meters) with a resolution of ± 1.2 inches (± 30 mm, or 0.29% of range).

In operation, a pulse is transmitted toward a target, and the resulting echo is detected. The elapsed time between initial transmission and echo detection can be used to find the distance by taking this round-trip time and multiplying it by the speed of sound. For a transmitted pulse to leave the transducer, strike a target 2 feet (0.61 meters) away, and return to the transducer, it requires 3.55 ms (1.78 ms per foot, or 5.84 ms per meter, during the round trip).

Essential to system operation is the transducer (shown disassembled in photo 5). It acts as a speaker in the transmit mode and as an electrostatic microphone in the receive mode. The transducer is 1.5 inches (38.1 mm) in diameter and consists of a 0.003 inch (0.07 mm)-thick gold-plated foil stretched over a concentrically

Photo 2: *Polaroid Ultrasonic Ranging System Designer's Kit, which includes ultrasonic sonar transducers, electronic circuitry, and a detailed specifications booklet.*



Photo 3: *Close-up view of the Polaroid Ultrasonic Transducer.*

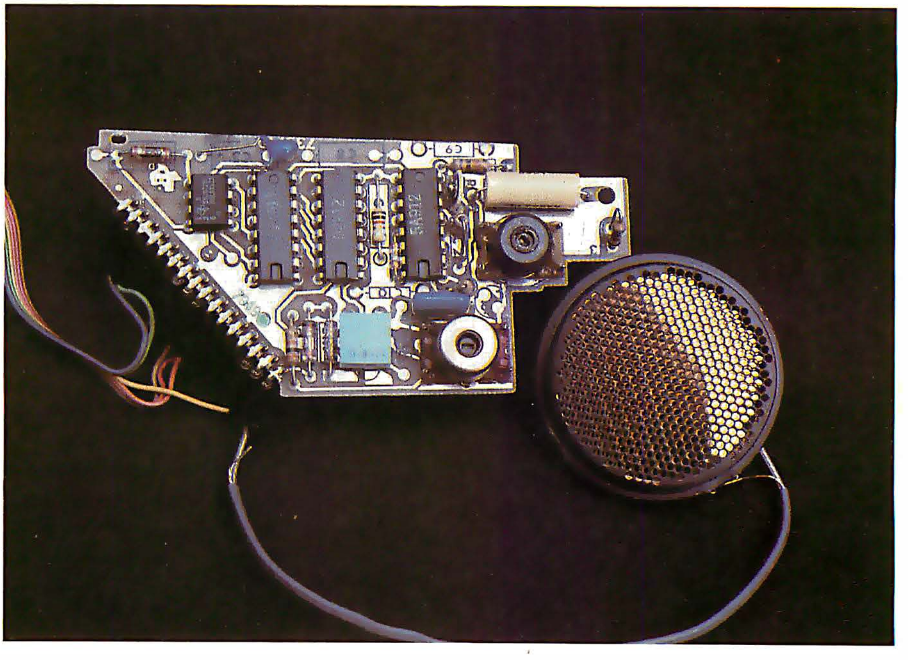


Photo 4: *Close-up of the ultrasonic circuit board, which contains custom analog and digital integrated circuits.*

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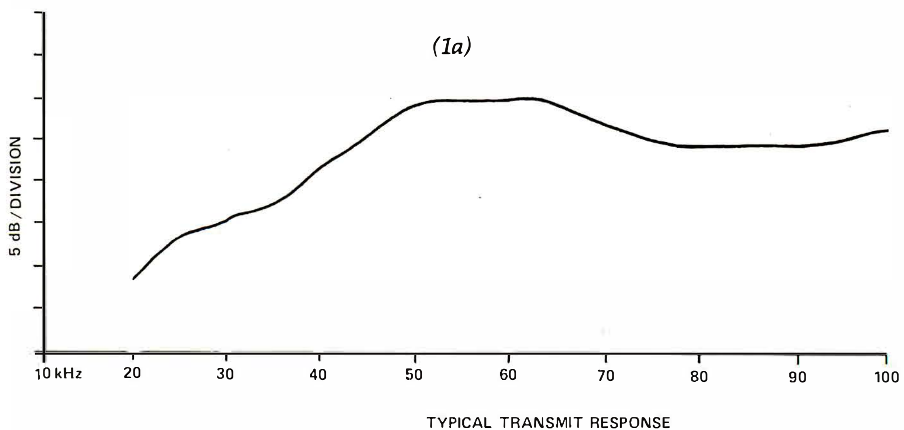
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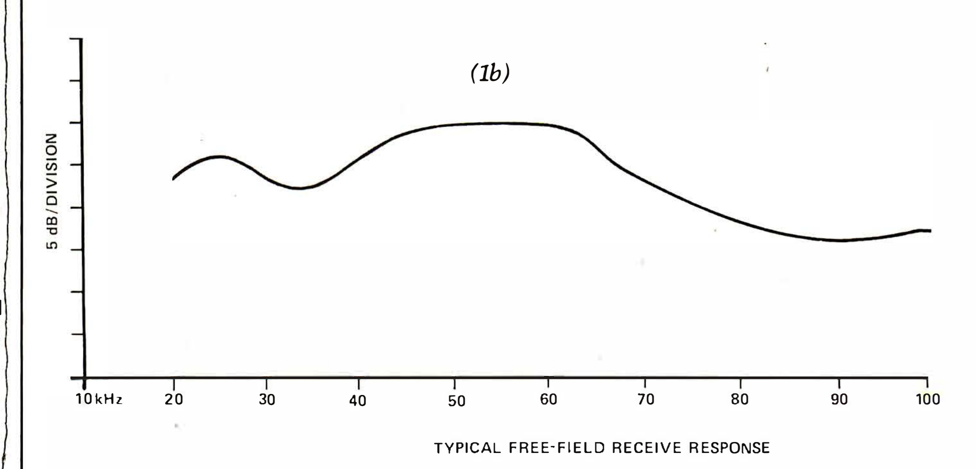
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grooved aluminum plate. When the metallic backplate is in proximity to the foil, it forms a capacitor. The foil is the moving element which converts electrical energy into sound and the returning echo into electrical energy.

The diameter of the transducer determines the directionality of the transducer. The acoustical signal-strength lobe pattern, or acceptance angle, during operation is shown in figure 1. The graph indicates that the transducer is fairly directional.

When the unit is activated, the transducer emits a sound pulse. The crystal-controlled electrical pulse





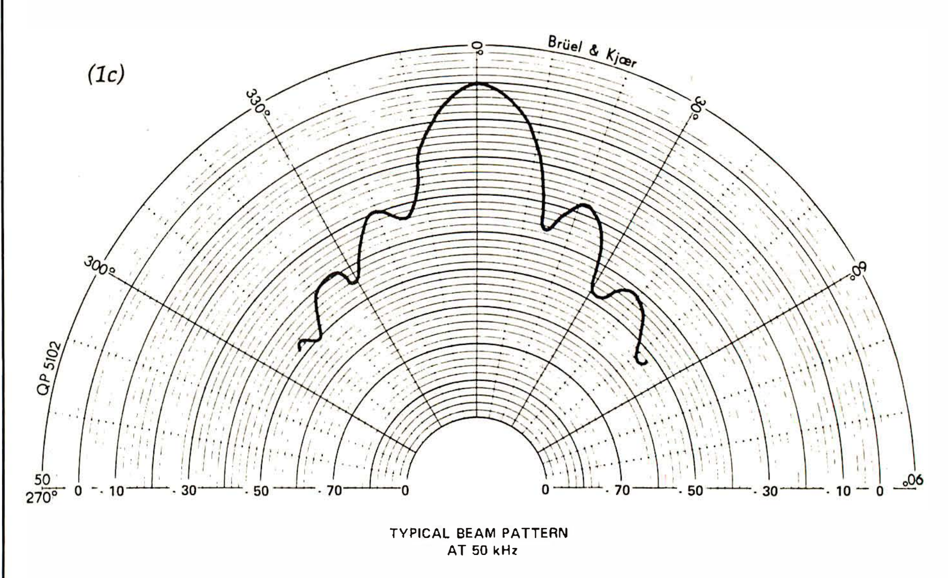


Figure 1: *Typical transmission frequency-response curve (1a), reception frequency-response curve (1b), and radial-beam pattern (1c) of the Polaroid ultrasonic transducer. The beam pattern was measured at 50 kHz, with dB values normalized to on-axis response.*

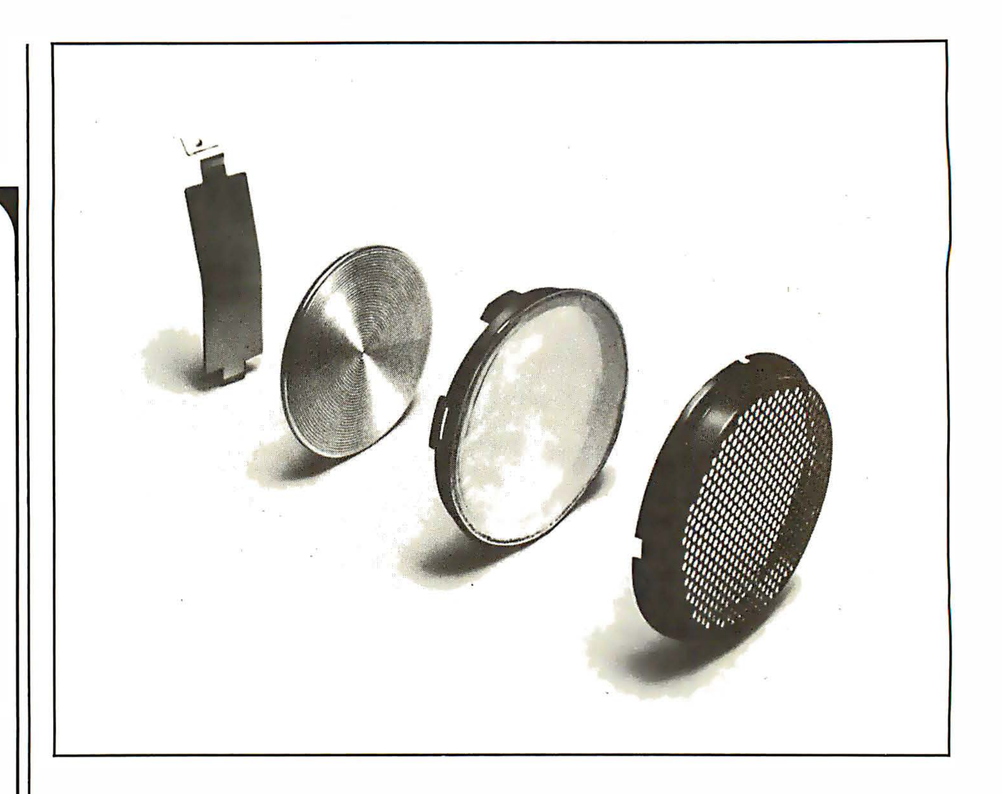


Photo 5: *Expanded view of the Polaroid ultrasonic sonar transducer. Behind a honeycomb grill, a 0.003-inch (0.07 mm)-thick gold-coated foil stretches over a concentrically grooved aluminum plate. The retainer at left holds the parts in place.*

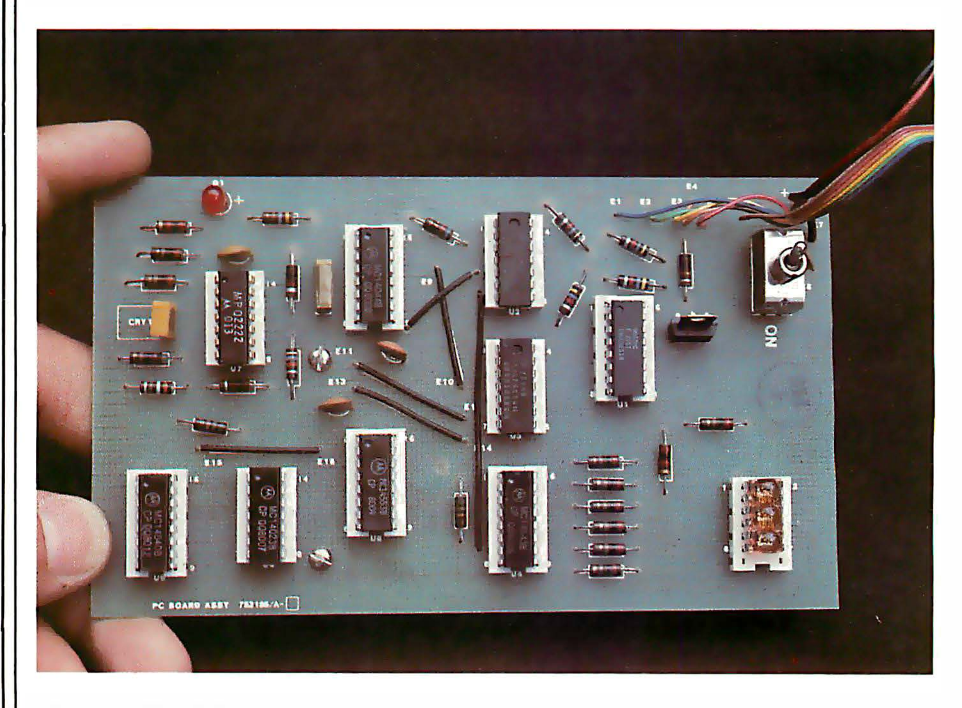


Photo 6: *The EDB, which contains the electronic circuitry shown in figure 4. The three-digit LED display is at the upper right.*

generated by the driver circuit is a 300 V high-frequency 1 ms "chirp" consisting of fifty-six pulses at four carefully chosen frequencies: eight cycles at 60 kHz, eight cycles at 57 kHz, sixteen cycles at 53 kHz, and twenty-four cycles at 50 kHz. This combination is used to overcome certain topographical characteristics of the area into which the signal is being transmitted, where a single frequency might be cancelled and no echo would be received.

Text continued on page 42

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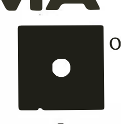
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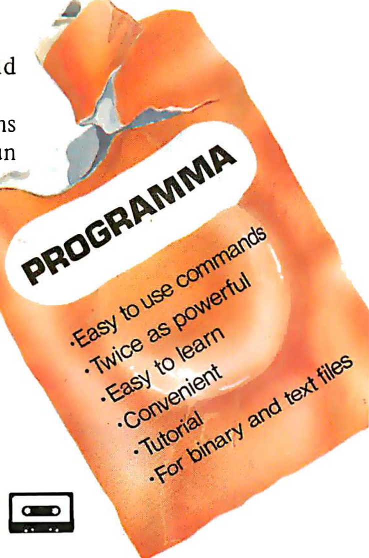
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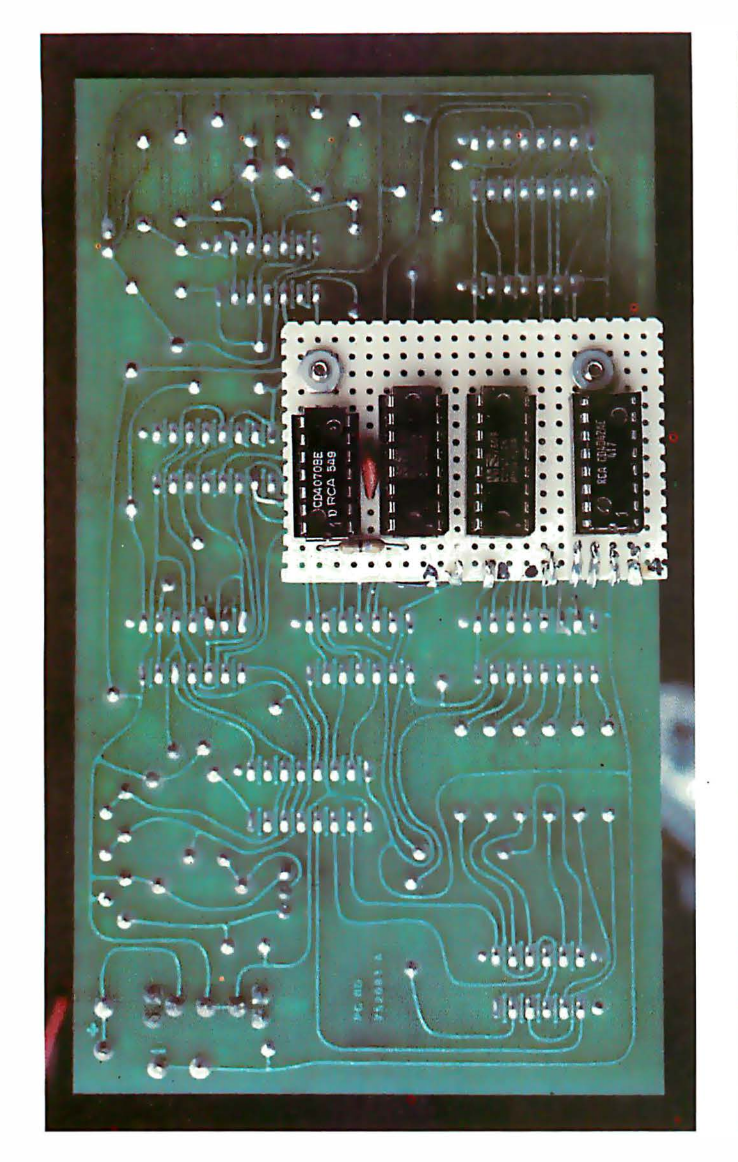
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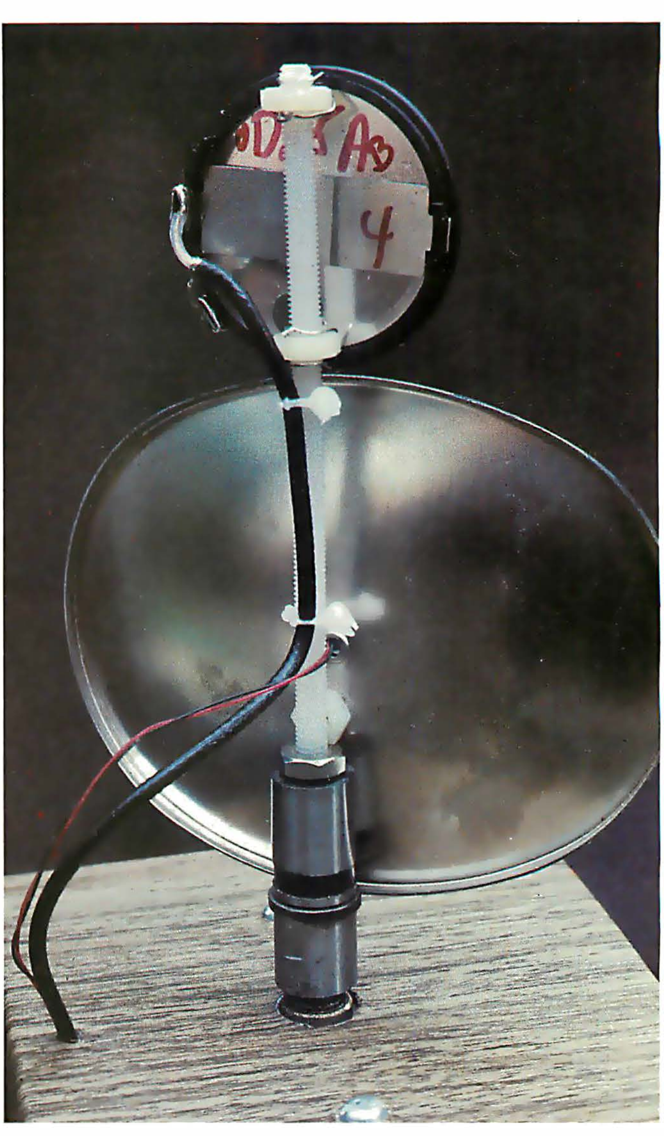


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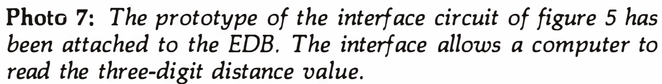


Photo 7: *The prototype of the interface circuit of figure 5 has been attached to the EDB. The interface allows a computer to read the three-digit distance value.*

Photo 8: *Close-up of the back side of the reflector and transducer of the scanner, showing the mounting apparatus.*

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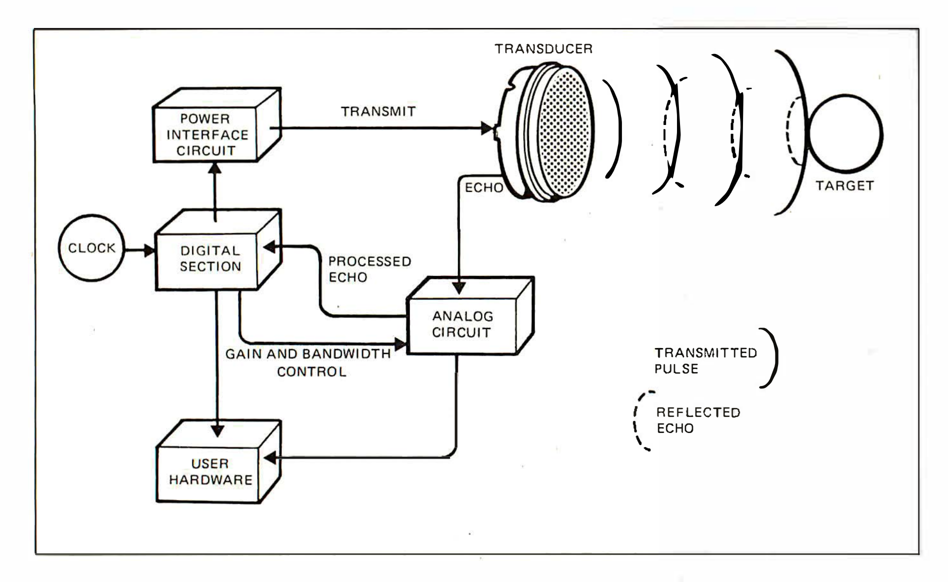


Figure 2: *Block diagram of the ultrasonic circuit. The circuit board contains a variety of custom components and is slightly modified from the unit used in SX-70 Land cameras. This circuit, as well as the EDB, is powered by a 6 V Polapulse battery. It seemed to work acceptably with a 5 VDC power supply.*

The block labelled "User Hardware" can be the EDB or any interface that can convert the ultrasonic circuit board's time-gated output into useful form.

Text continued from page 38:

The ultrasonic circuit board controls both the transmit and receive operating modes. It contains both digital and analog circuitry. In addition to transmitting the chirp and processing the echo, this circuit also tailors the amplifier sensitivity depending upon the object distance. Lower amplification is needed for close echoes, while higher amplification is needed for distant echoes. This is accomplished by increasing the amplifier gain and Q (ratio of reactance to resistance) in steps. Figure 2 is a block diagram of the ultrasonic circuit board.

Experimental Demonstration Board

The ultrasonic circuit board previously described is a modified camera assembly. The EDB (Experimental Demonstration Board, shown in photo 6) is not a camera component; it was designed specifically as a user interface to the ultrasonic board.

Text continued on page 48

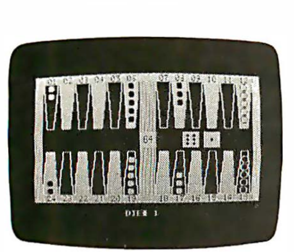
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SET REFERENCE LATCH RESET
LC
SET RESET ECHO LATCH
LE
420 kHz CLOCK CIRCUIT
AC COUPLING
AC COUPLING
CLK
SR ⊥
SR ⊥
OF ⊥ 1000 COUNTS OF A7 178 ms
DLE
CLOCK RESET TIME-TO-DISTANCE CONVERSION
MASTER RESET
LATCH ENABLE
3-DIGIT BINARY COUNTER
A1 4.6 μs PER CYCLE
SCANNING CLOCK
CLOCK INPUT
A7 1.2 INCHES/CYCLE 178 μs/CYCLE
SCANNING OUTPUTS
MULTIPLEXED BCD OUTPUTS
DS3 DS2 DS1
Q3 Q2 Q1 Q0
3-DIGIT DISPLAY
DRIVE CIRCUIT
BCD-TO-SEVEN-SEGMENT CONVERSION
DRIVE CIRCUIT

Figure 3: *Block diagram of the Polaroid Experimental Demonstration Board.*

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Gammon Gambler

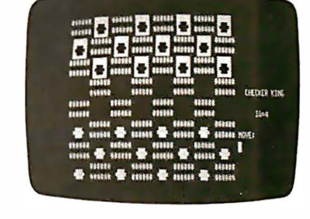
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Checker King

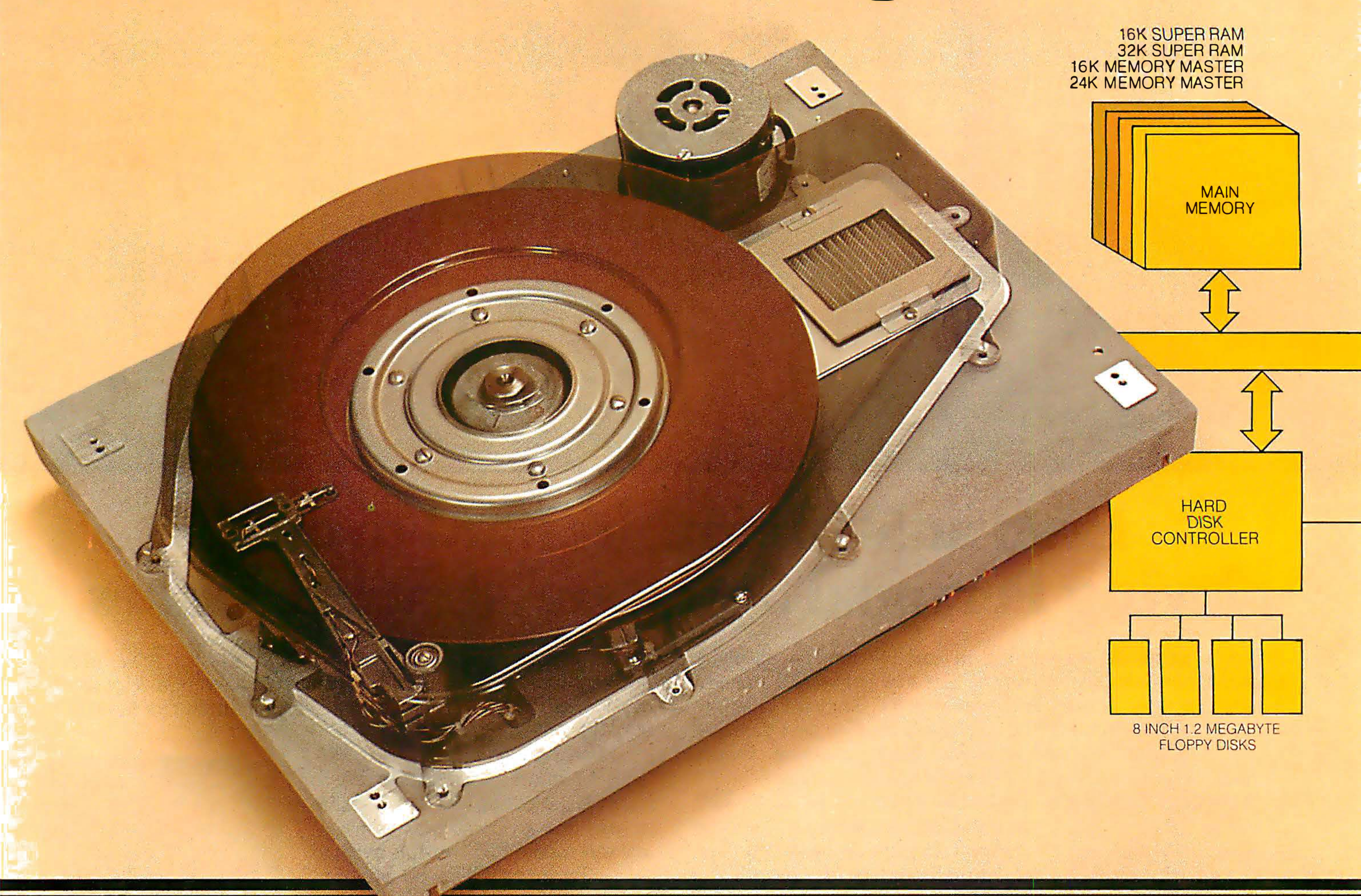
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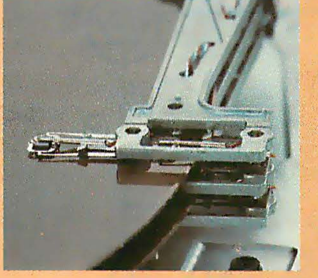
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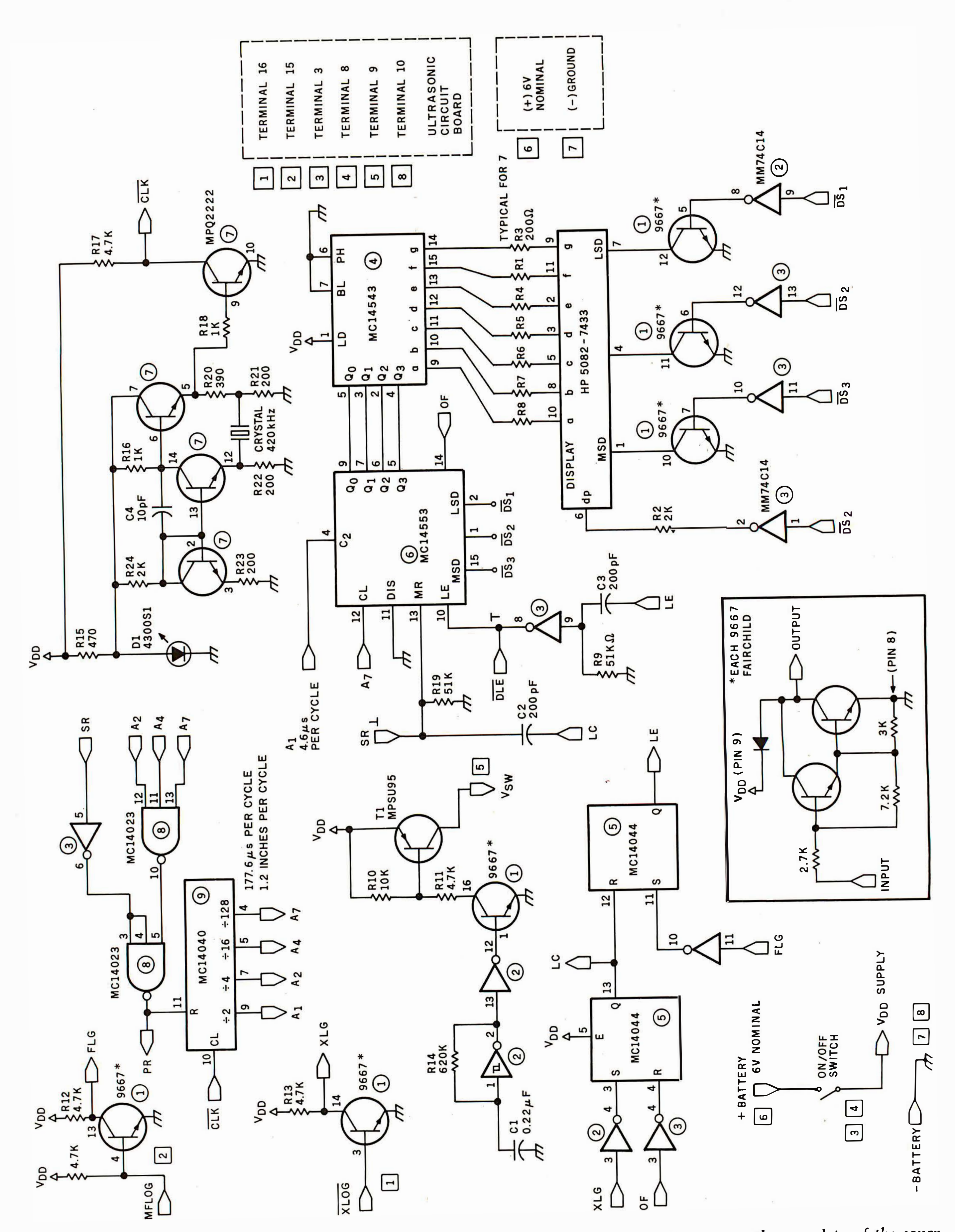


Figure 4: *Schematic diagram of the EDB. This board contains all the necessary circuitry to convert the raw data of the sonar transmit/receive time interval into a numeric distance value and display it on a three-digit LED display.*

Bit 1	Bit 0	Output Digit to Computer
0	0	$\overline{DS_1}$ (LSD)
0	1	$\overline{DS_2}$
1	0	$\overline{DS_3}$ (MSD)
1	1	n/a

Table 1: *Correspondence of the 2-bit digit-select codes with the EDB output data sent to the computer.*

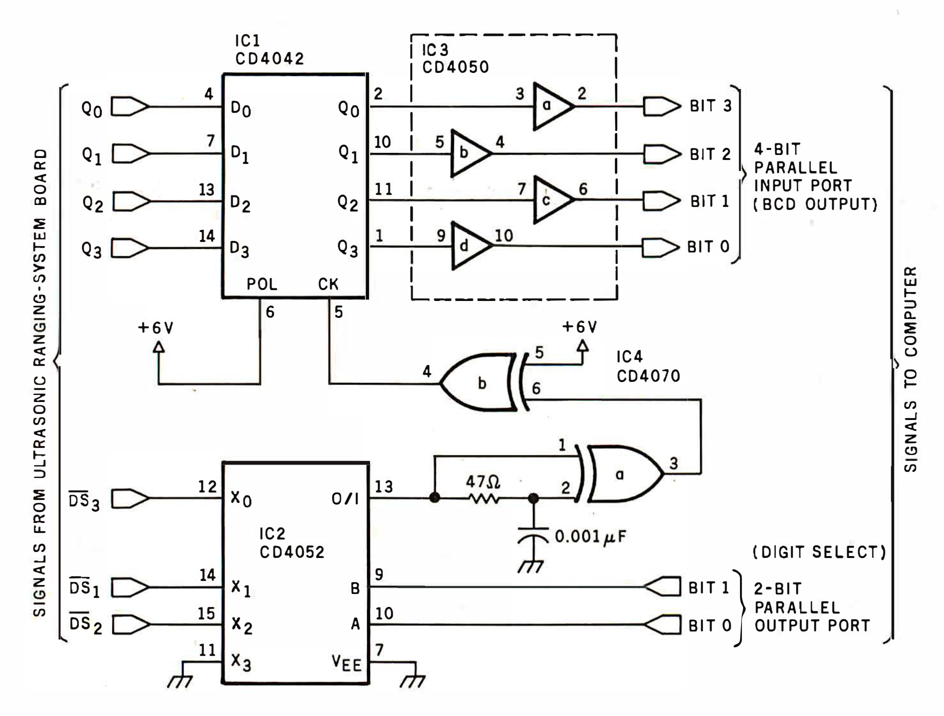


Figure 5: *Schematic diagram of an interface that allows a computer to directly read the three-digit LED display of the EDB, using four integrated circuits. Through 2 bits of a parallel output port, the computer sends a digit-select code and then reads the corresponding BCD value of the selected digit through 4 bits of a parallel input port.*

Number	Type	+6 V	GND
IC1	CD4042	16	8
IC2	CD4052	16	8
IC3	CD4050	1	8
IC4	CD4070	14	7

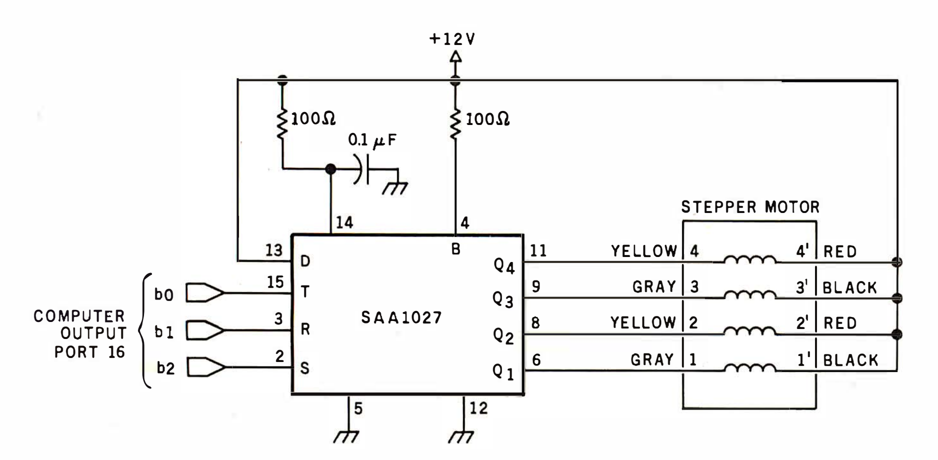


Figure 6: *Stepper motor and controller used in the infrared and ultrasonic scanner. The motor is a North American Philips K82701-P2 type, which turns 7.5° per step. It operates on 12 VDC.*

The SAA1027 integrated circuit is available from Signetics or from North American Philips, Cheshire, Connecticut, (203) 272-0301.

Text continued from page 42:

The EDB contains all the necessary electronic circuitry to convert the transmit/receive time interval into a figure indicating distance (in feet) and present it on a three-digit LED (light-emitting diode) display. Figure 3 is a block diagram of the EDB, while figure 4 shows the schematic diagram.

Connecting the EDB to the computer requires some thought. The output of the EDB is a three-digit display with a numeric output range of 00.9 to 35.0 in increments of 0.1 feet. The multiplexed display is controlled by a three-digit binary counter with strobed digit-select lines. It uses a single BCD (binary-coded decimal)-to-7-segment decoder/driver. At any instant, only one digit is energized, but because of the persistence of human vision, they all appear to be illuminated. Unfortunately, this multiplexed display output is not very computer-compatible and requires additional interface circuitry.

Decoding the EDB Output

Figure 5 is the schematic diagram of a four-integrated-circuit interface that decodes the counter output on the EDB and latches the digits while the computer reads them. Essentially the circuit consists of a three-input demultiplexer (IC2), an edge detector (IC4), a 4-bit latch (IC1), and an output buffer (IC3). The four-chip circuit is conveniently mounted on a piece of perforated circuit board and attached to the rear of the EDB, as illustrated in photo 7.

When the MSD (most-significant digit) of the LED display is energized, the $\overline{DS_3}$ line is low. The data on Q_0 thru Q_3 at this time form the BCD value of that number. Similarly, when $\overline{DS_2}$ goes low, the data lines will hold the second digit value. IC2 is a 4-to-1-line demultiplexer with the three digit strobes as inputs. A 2-bit TTL (transistor-transistor logic)-compatible parallel output from the computer determines which of these channels is routed through the multiplexer. To get $\overline{DS_1}$, the LSD (least-significant digit), the input code to the EDB interface would be 00. A binary code of 10 would set channel 3, allowing $\overline{DS_3}$ to go through. A summary of the codes is given in table 1.

The inputs to IC2 are offset by one channel due to the peculiar timing of the EDB. While the $\overline{DS_3}$ line is



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physically tied to channel 0 and would appear to be addressed with a 00 input code, the edge-detector timing of the circuit is such that we are not latching the current digit's value, but the *next* digit's value, when we address the channel. However illogical it may seem, the codes that work are stated in table 1.

When we have selected which digit we want to read by setting the proper multiplexer-input code, that digit value will be latched into IC1 and available as a BCD value to the computer. IC3 buffers the CMOS (complementary metal-oxide semiconductor) voltage levels of the EDB to the TTL level required by most computers. To read a three-digit range, we simply set the three multiplexer codes in succession. To obtain the distance indication, just add the three values as follows:

Distance = (MSD) × 10 + (2nd digit) × 1 + (LSD) × 0.1

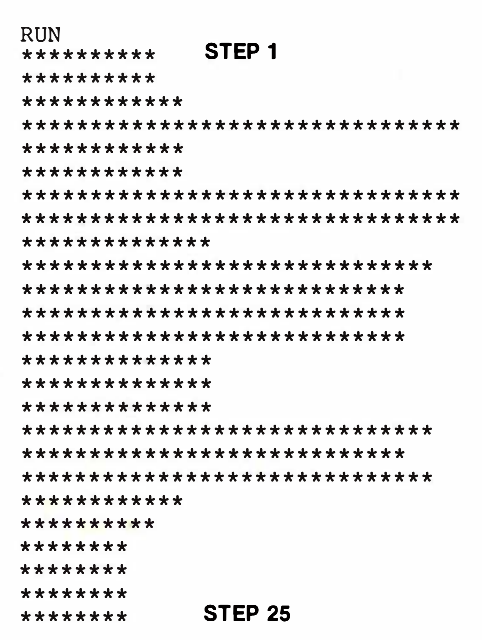
This interface design is essentially speed-independent and can be driven equally well by an assembly-language or BASIC program. Listing 1 is a BASIC program that reads and displays the three-digit range determined by the ultrasonic ranging system.

A More Sophisticated Scanner

The original article, "I've Got You in My Scanner!," previously mentioned, has been reprinted in the book *Ciarcia's Circuit Cellar*, volume 1, available from BYTE Books. Photo 8 is a close-up of the updated version of the scanner, which now includes the ultrasonic ranging detector. The basic scanner consists of a North American Philips stepper motor (12 V type K82701-P2) and integrated-circuit controller (SAA1027) with an infrared-sensitive photo Darlington transistor (General Electric type L14F2) fixed at the focus of a parabolic reflector mounted on the shaft. I used a Radio Shack solar cigarette lighter, catalog number 61-2797, as the parabolic reflector. The driver circuit for the stepper motor is outlined in figure 6. The original article explained the infrared sensing system in detail.

The new scanner has the ranging detector mounted on the stepper-motor shaft, above the parabolic reflector. Both point in the same direction. The stepper motor is driven through the SAA1027 with 3 bits of a parallel output port. To drive the motor clockwise, bit 1 is set low, bit 2

Text continued on page 56



```
RUN
**********          STEP 1
**********
************
********************************
************
************
********************************
********************************
**************
******************************
****************************
****************************
****************************
**************
**************
**************
******************************
****************************
******************************
************
**********
********
********
********
********          STEP 25
```

Figure 7a: *Bar graph of distance measurements taken by the scanning system as the ultrasonic transducer was pivoted in twenty-five steps through a 180° sweep around the Circuit Cellar (each asterisk represents approximately one-half foot). Note correspondence with floor plan in figure 7b.*

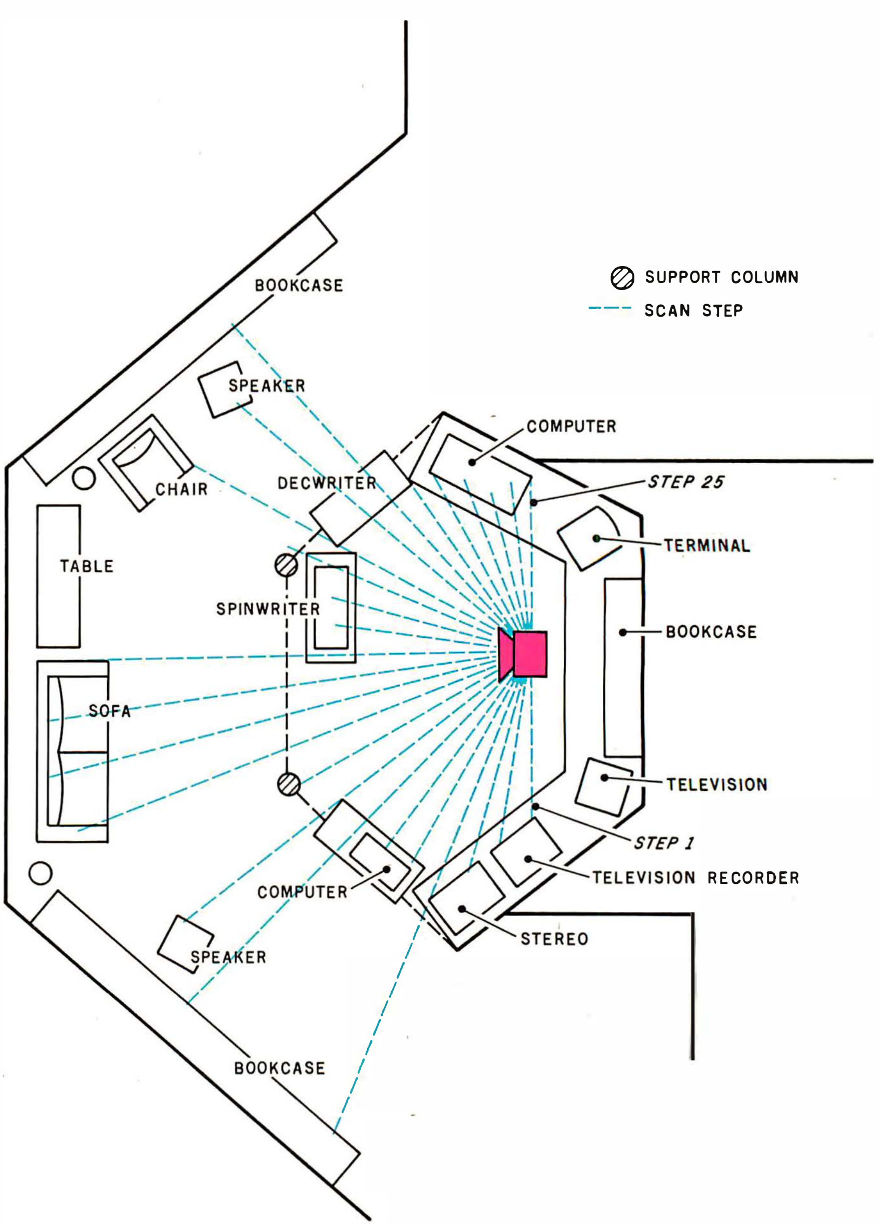


Figure 7b: *Floor plan of Circuit Cellar showing location of scanner and beam paths to room objects during the twenty-five steps in the scanning sweep. Bar graph of figure 7a shows relative distance to the nearest obstruction in the beam path at each step.*



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Listing 1: *A BASIC program that uses the interface circuit shown in figure 5 to read the three-digit distance value from the EDB and display the distance on the computer printer. A sample execution follows the BASIC-language statements.*

```
100 REM   THIS PROGRAM ALLOWS A COMPUTER TO READ AND DISPLAY
110 REM   DISTANCE AS MEASURED BY THE POLAROID ULTRASONIC
120 REM   RANGING SYSTEM DEMONSTRATOR BOARD. RANGE .9 TO 35 FT.
130 REM
140 REM
150 GOSUB 250
160 PRINT"DISTANCE TO TARGET IS ";S;" FEET"
170 GOTO 150
180 REM
190 REM
200 REM   THIS ROUTINE SETS AND READS THE 3 DIGITS ON THE
210 REM   RANGING BOARD.
220 REM   IT IS A THREE STEP PROCESS: SET THE DIGIT; READ THE
230 REM   DIGIT VALUE; AND MASK OFF EVERYTHING EXCEPT THE 4 BIT
240 REM   CHARACTER.
250 FOR T=0 TO 2
260 OUT 16,T
270 S(T)=INP(16)
280 S(T)=S(T) AND 15
285 S=(S(2)*10)+(S(1)*1)+(S(0)*.1)
290 NEXT T
300 RETURN


RUN

DISTANCE TO TARGET IS  3.3  FEET
DISTANCE TO TARGET IS  3.4  FEET
DISTANCE TO TARGET IS  3.5  FEET
DISTANCE TO TARGET IS  3.4  FEET
DISTANCE TO TARGET IS  3.3  FEET
DISTANCE TO TARGET IS  3.4  FEET
DISTANCE TO TARGET IS  3.3  FEET
DISTANCE TO TARGET IS  3.4  FEET
DISTANCE TO TARGET IS  3.4  FEET
DISTANCE TO TARGET IS  3.5  FEET
DISTANCE TO TARGET IS  3.3  FEET
```

Listing 2: *A BASIC program that causes the scanner to make a 180° scanning sweep in twenty-five steps and prints the distance measurements in the form of a bar graph. Figure 7a shows the output from the execution of this program on the system set up in the Circuit Cellar.*

```
100 REM THIS PROGRAM MAKES A 180 DEGREE SCAN AND RECORDS THE
110 REM DISTANCE TO SOLID OBJECTS EVERY 7.5 DEGREES.
120 REM
130 REM STEPPER MOTOR CONTROLLER ATTACHED TO PORT 18
140 REM ULTRA SONIC RANGING UNIT ATTACHED TO PORT 16
150 REM
160 REM
170 DIM Z(25)
180 OUT 18,1 :OUT 18,255 :REM PRESET STEPPER CONTROLLER
190 REM
200 REM CLOCKWISE SCAN
210 REM BIT 2 IS SET HIGH AND BIT 0 IS TOGGLED
220 FOR D=0 TO 24
230 OUT 18,5
240 GOSUB 470
250 OUT 18,4
260 NEXT D
270 REM
280 REM COUNTERCLOCKWISE SCAN
290 REM BITS 1 AND 2 ARE HELD HIGH AND BIT ZERO IS TOGGLED
300 FOR D=0 TO 24
310 OUT 18,7
320 GOSUB 570
330 OUT 18,6
340 NEXT D
350 REM
```

Listing 2 continued on page 56

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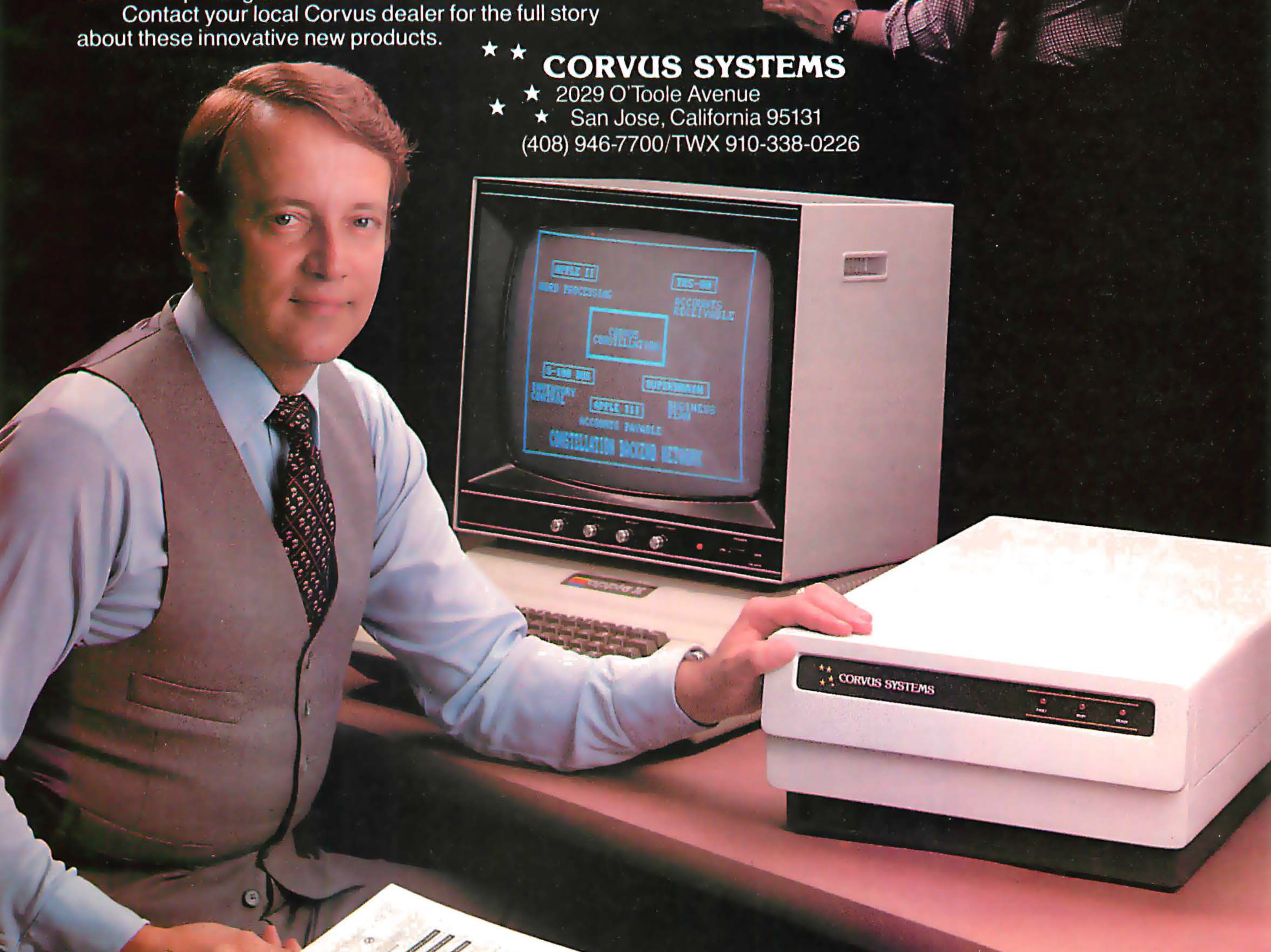
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IN CONTROL

Listing 2 continued:

```
360 REM
370 REM PLOT RANGES AS BAR GRAPH
380 FOR D=0 TO 24
390 FOR W=1 TO INT(Z(D))
400 PRINT"**";
410 NEXT W
420 PRINT" "
430 NEXT D
440 GOTO 220
450 REM
460 REM
470 REM STEP DELAY AND RANGE SAMPLE ROUTINE
480 FOR T=0 TO 2
490 OUT 16,T
500 S(T)=INP(16) :S(T)= S(T) AND 15
510 NEXT T
520 Z(D)=(S(2)*10)+(S(1)*1)+(S(0)*.1)
530 FOR Q=0 TO 10 :NEXT Q
540 RETURN
550 REM
560 REM
570 FOR Q1=0 TO 100 :NEXT Q1
580 RETURN
```

Listing 3: *A short BASIC program that demonstrates one method for using the ultrasonic scanning device in a security system.*

```
100 REM THIS PROGRAM DEMONSTRATES HOW THE ULTRASONIC RANGING
110 REM BOARD CAN BE USED AS AN INTRUSION DETECTOR.
120 REM
130 REM
140 A=1 :GOSUB 220 :REM  TAKE FIRST DISTANCE READING
150 GOSUB 330
160 A=2 :GOSUB 220 :REM  TAKE SECOND DISTANCE READING
170 IF ABS(X(1))-ABS(X(2))>=.3 THEN GOTO 280
180 IF ABS(X(2))-ABS(X(1))>=.3 THEN GOTO 280
190 GOTO 140 :REM CONTINUE SCAN
200 REM
210 REM
220 FOR T=0 TO 2
230 OUT 16,T
240 S(T)=INP(16) :S(T)=S(T) AND 15
250 NEXT T
260 X(A)=(S(2)*10)+(S(1)*1)+(S(0)*.1)
270 RETURN
280 PRINT" I GOT YOU IN MY SCANNER AT ";X(2);" FEET."
290 REM AN ALARM ROUTINE WOULD BE PLACED HERE
300 GOTO 140
310 REM
320 REM
330 REM SAMPLE RATE DELAY TIMER
340 FOR Y=0 TO 200 :NEXT Y
350 RETURN



RUN

I GOT YOU IN MY SCANNER AT 11.4 FEET.
```

Text continued from page 50:
is held high, and bit 0 is toggled to produce each step. To drive the motor counterclockwise, bits 1 and 2 are held high, and bit 0 is toggled for each step. The new scanner can read the distance at each step.

Listing 2 is a program that causes the scanner to make a 180° scan and prints out the distance measurements in the form of a bar graph, demonstrated here in figure 7a.

To help you understand the mode of operation and value of the ranging device, I have also sketched the area of the Circuit Cellar where the measurements were taken. (See figure 7b.)

The scanner (the red object in figure 7b) was placed on a tripod at a



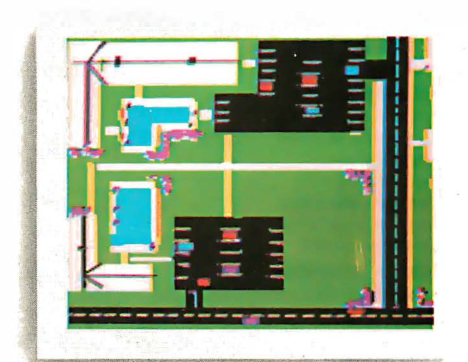
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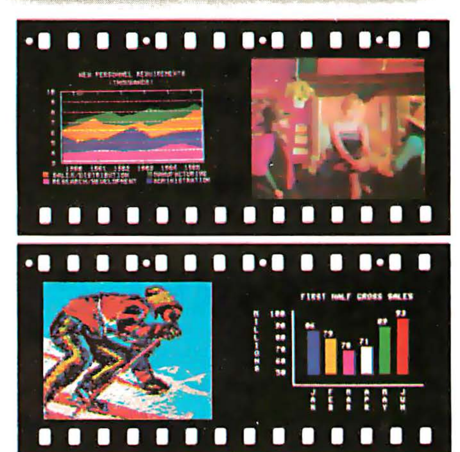
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height of 5 feet (1.5 meters), about 2 feet (0.6 meters) in front of my desk area. The parabolic reflector was pointed 90° to the left of center so that a 180° scan resulted in it ending up pointing 90° right of center. At each of the twenty-five steps it took to reach this point, it measured the distance to the nearest obstruction to its line of detection. For comparison, the blue dotted lines in figure 7b show where each step should have been and what should have been in the way of the sonar "beam."

The program of listing 2 printed the graph bar corresponding to each step, starting with step 1. At the position reached after step 1, the system recorded a distance of about 5 feet (1.5 meters) to the VTR (videotape recorder) on the counter top. The same result was obtained for the next two steps. At the position reached after step 4 (about 30° around), the scanner was pointing between the stereo system and the TRS-80 computer on the desk to the right. This was indicated by a reading of about 15 feet (4.6 meters), measuring the distance to the bookcase on the far wall.

The next couple of steps had the TRS-80 directly in the path of the scanner beam, and then the path of the beam was open to the far wall again for a couple of steps. The rest of the scan was similarly significant in that the range detector accurately described the perimeter from its viewpoint. Most important, however, was the demonstration of the sensitivity of the ranging device. At steps 9 and 16, the only object in the path between the scanner and the wall was a 4-inch (10 cm) ceiling-support column about 7 feet (2.1 meters) away. In both cases the obstruction was accurately identified.

We now have a device that can rotate to a particular position and accurately measure the distance to any object it "sees." A practical use of the range detector is as a security device. When the wall is known to be 16 feet (4.8 meters) away from the scanner, a sudden reading of 9 feet (2.7 meters) indicates that someone or something just moved in front of the range detector. The program of listing 3 allows the range detector to be used as a motion detector.

In Conclusion

I have demonstrated only two uses for the Polaroid Ultrasonic Ranging System Demonstrator Kit. The majority of applications I've heard about thus far have been independent projects that utilize the ranging system *without* the additional capabilities of a computer. They include a walking cane (with audio feedback) for the visually handicapped, a 0 to 35 foot (0 to 11 meter) altimeter for the *Gossamer Albatross* aircraft (for its English Channel crossing), and as an electronic "dip stick" for measuring liquid levels in storage tanks.

I hope that once you realize how easy it is to attach this automatic ranging system to a computer, you'll have as much fun experimenting with it as I have. Unfortunately, a new problem has arisen. Until now, one of the major reasons I haven't attempted to build a robot was the amount of expense and technical effort required to make it "see." Now I'll have to find a new excuse. ■

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OUR MESSAGE.

Technical Forum

Kinetic String Art for the Apple

Louis Cesa, 305 Doris Ave, Vestal NY 13850

The accompanying photographs were produced using high-resolution graphics on the Apple II computer. As interesting as the pictures are, they do not do justice to the real-time art that takes place on the screen. The photographs show only time slices at different stages in the development of the kinetic string art. On the screen one can see shapes forming and gradually being replaced by other shapes in a continuous display of color and motion.

Algorithm Description for Kinetic String Art Program

1. *Initialize Variables:*
X1=X2=Y1=Y2=CNT1=CNT2=0;
DIM C(150), TX1(150), TX2(150), TY1(150), TY2(150);
AT=1

2. *Erase the line from* TX1(AT), TY1(AT) *to* TX2 (AT), TY2(AT) *of color* C(AT).

3. *If* CNT1=0 then choose a new random color and a new random CNT1.
COLOR=1+RND(3)
CNT1=5×(1+RND(10))

4. *If* CNT2=0 *then choose new step sizes for* DX1, DY1, DX2 *and* DY2 *and a new random* CNT2:
DX1=RND(9)−4
DY1=RND(9)−4
DX2=RND(9)−4
DY2=RND(9)−4
CNT2=5×(1+RND(10))

5. *Compute new* X1, Y1, X2, Y2 *for next line and test for screen boundaries. For example,*

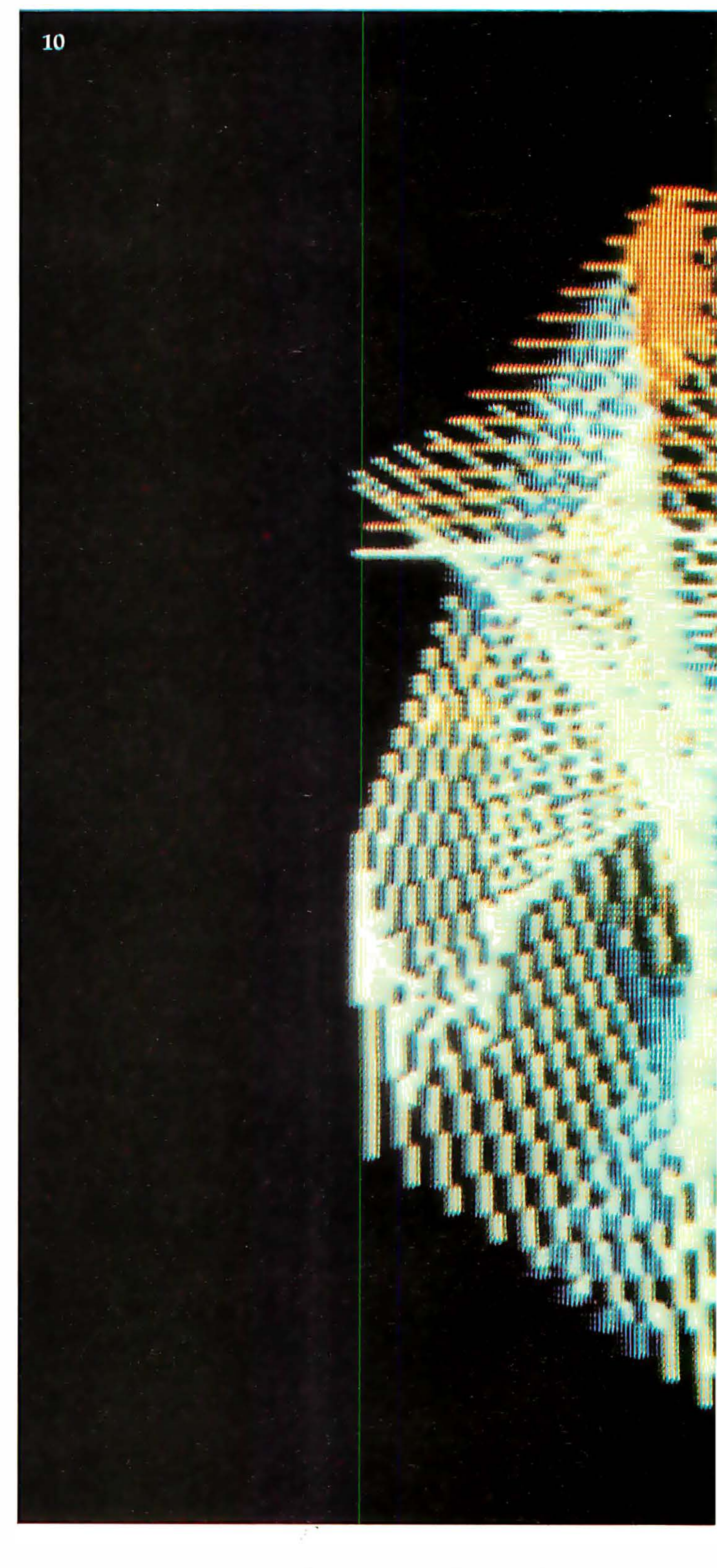
```
470 PX1=X1+DX1
480 IF PX1>=0 AND PX1<= MX THEN 500
490 PX1=X1: DX1=-DX1
500 X1=PX1
```

6. *Draw the new line from* X1, Y1 to X2, Y2.
7. *Store the coordinates and color of the new line in:*

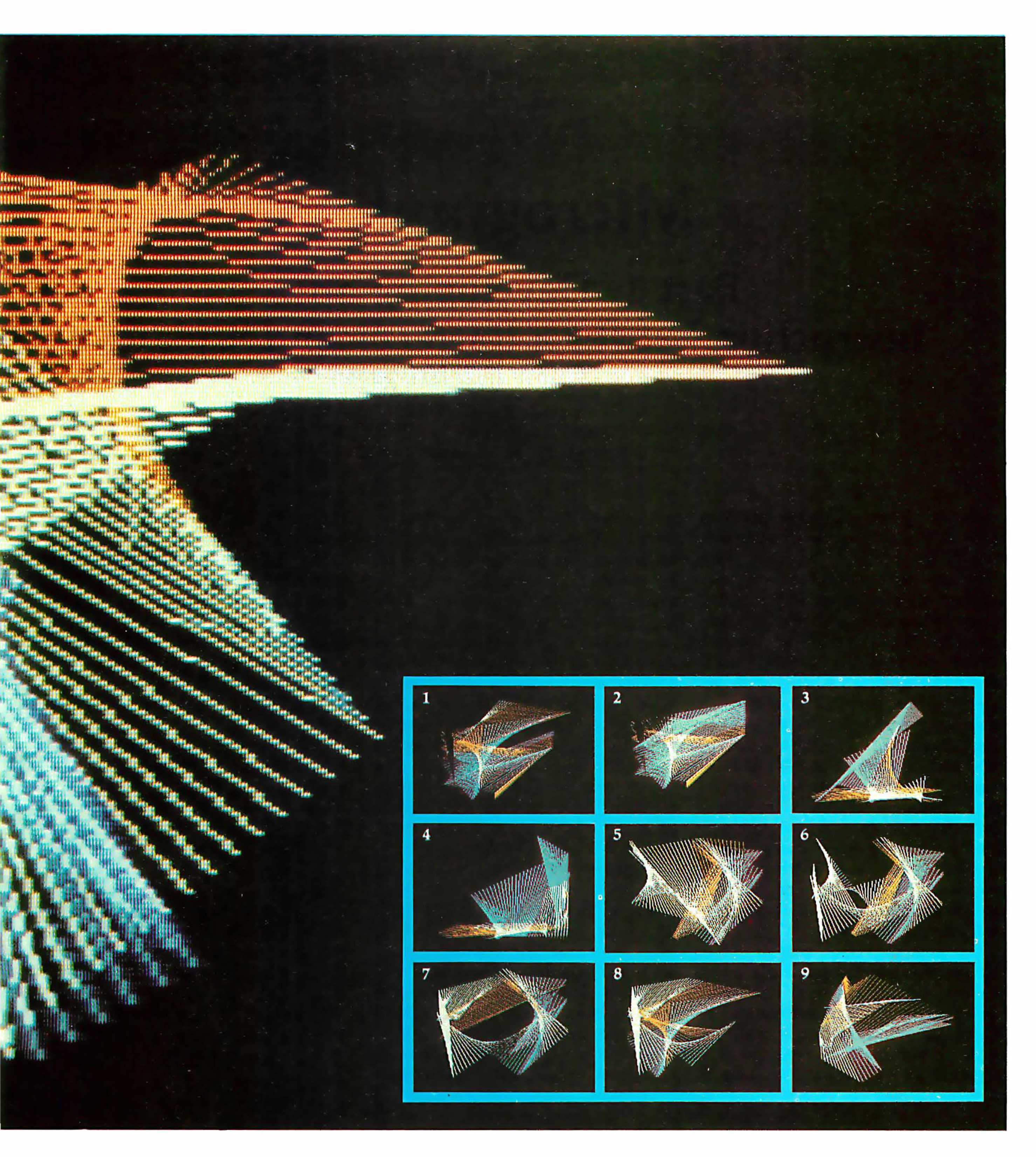
C(AT), TX1(AT), TX2(AT), TY1(AT), TY2(AT)

8. *Step AT to next position in table.*
AT=AT+1
IF AT > 150 THEN AT=1

9. *Go to step 2.*



The algorithm used is quite simple. (See textbox. Contractual agreements preclude publishing a listing of the program.) The pictures are drawn by a line segment making a random walk on the screen. An initial pair of endpoints is chosen at random; also chosen at random are color, number of lines to be drawn with that color, step size for each endpoint (in the x and y directions), and number of times that the step sizes are to be used. Successive lines are drawn by advancing the endpoints of the line by the chosen step size in the x and y directions.



Whenever the number of times that an action was to be executed (such as number of lines to be drawn in a given color) is exhausted, new random values for that quantity and for the number of times that the quantity should be used, are chosen. If a point attempts to walk off the screen, it is reflected back.

The designs in the accompanying photographs are formed by 150 lines. The program was coded so that when the 151st line is added, the first line is deleted, and so on. This is done by a routine that keeps track of each line segment currently on the screen. When the table contains 150 lines, this routine erases the oldest line segment before adding a new one. (This effect can be noted in photos 1 and 2.) Interesting effects can be obtained by using different algorithms to choose the new line to be added at each iteration. For example, an interesting effect is obtained with just 10 lines on the screen and choosing random endpoints for each new line (essentially a visual image of white noise).■

Micrograph

Part 1: Developing an Instruction Set for a Raster-Scan Display

E Grady Booch
4314 Driftwood Dr
Colorado Springs CO 80907

Simply stated, computer graphics is the technique of visual communication from computer to man. (See reference 14.) Interactive computer graphics is an important subset of this broad field and relates to computer-generated displays that can interact with a user in real or near-real time. Interactive graphics started with attempts to use the CRT (cathode-ray tube) as a computer output device. (See reference 12). The Whirlwind I in 1950 and Sketchpad in 1963 are examples of early attempts at interactive computer-graphics systems. Since that time, two distinct classes of CRT-based devices have been developed for use in interactive graphics: calligraphic (or vector) devices and raster-scan (as in a television receiver) devices.

The area of vector graphics "has for several years been sufficiently mature to justify efforts at standardization within it." (See reference 8.) A large body of information is available on the design of such systems. (See reference 13.) However, the same is not necessarily true of raster-scan devices. Until recently, raster-scan technology has not been economically feasible. Decreasing hardware costs, especially for memory, have facilitated the trend toward raster-scan displays. (See reference 3.) The emergence of raster-scan displays has a side benefit, namely that "raster-scan technology is the only economical way to achieve color in full-sized displays." (See reference 4.)

For the microcomputer user, this means that he can add moderate-resolution color graphics to a system at an affordable price, using raster-scan technology. The benefits of color graphics for the personal computer are obvious: not only are color displays dazzling and eye-catching, but more important, they add a new dimension for communicating with a computer. Microcomputers with color-graphics capabilities have been available for some time, such as the Apple II and the Compucolor. Within the past year, however, Motorola and AMI (American Microsystems Incorprated) have released a LSI (large-scale integration) chip, called a video-display generator, which performs all the video functions necessary to produce a color-graphics and alphanumerics display on a standard, unmodified color television. As a result, low-cost color-graphics displays are now possible for the personal computer user.

This three-part article presents the theory, design, and construction of a low-cost, color-graphics display processor called Micrograph, which is based on the Motorola MC6847 video-display generator. (See photo 1.) Essential characteristics of Micrograph are described in the text box. In the remainder of this article, I will review the characteristics of interactive computer-graphics systems, followed by an overview of the Micrograph design. Subsequent articles will concern the hardware construction details for Micrograph and the software necessary to control the system.

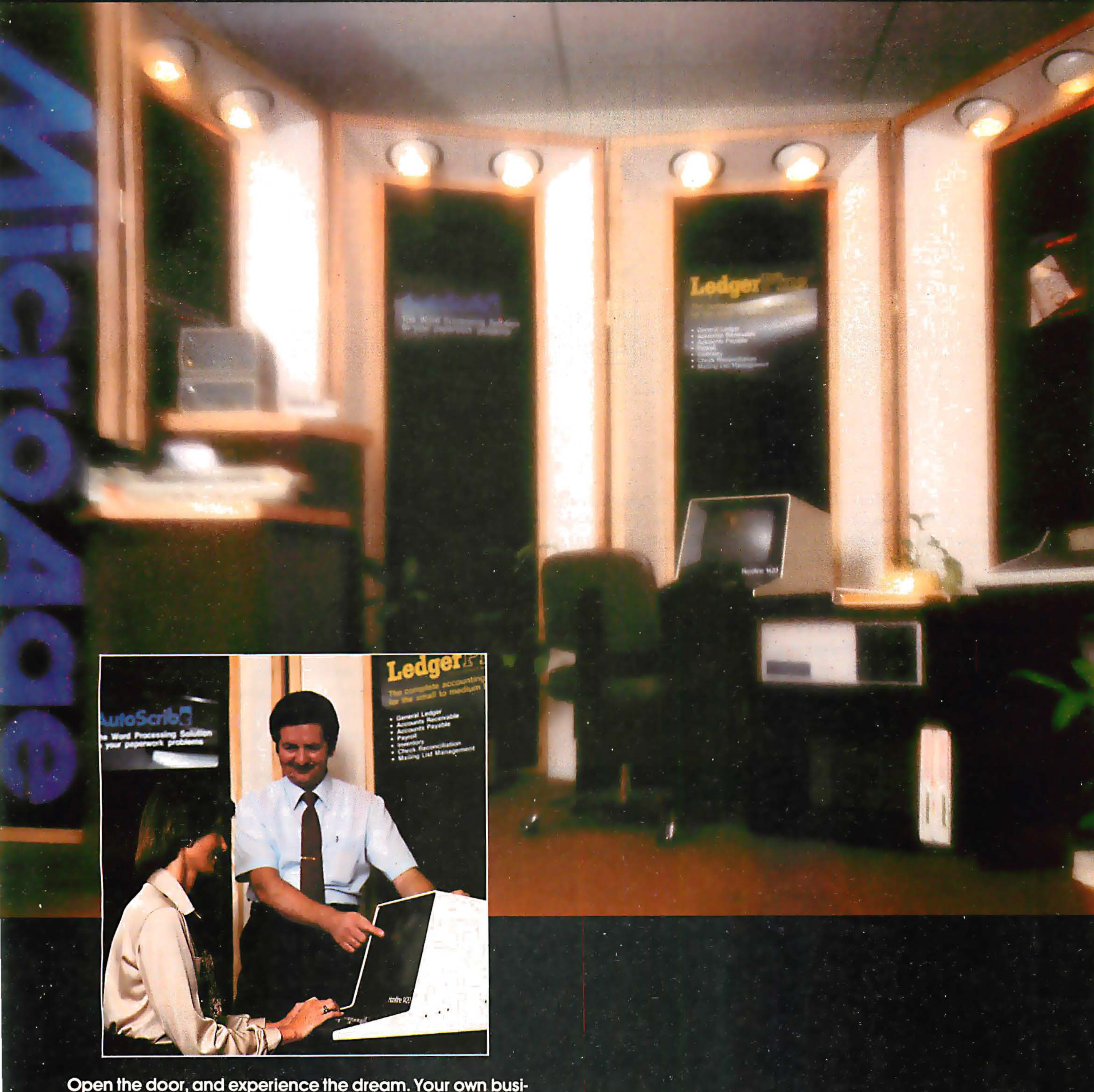
About the Author

E Grady Booch is currently a computer systems design engineer with the Air Force Space and Missile Test Center. He is involved with the development of a high-resolution color-graphics system for tracking missile launches. Grady received his bachelor of science and master of science degrees in computer science from the United States Air Force Academy and the University of California, Santa Barbara, respectively.

Micrograph Features:

- *64 by 64, 128 by 128, and 256 by 192 pixel resolutions are available.*
- *Up to eight different colors are displayed at one time.*
- *It contains a single-board processor, based on Zilog Z80 processor and Motorola MC6847 Video Display Generator.*
- *Construction cost: about $275 .*
- *High-level graphics primitives support.*
- *Both graphics and alphanumerics are supported.*
- *It interfaces to a host microcomputer via three 8-bit input/output ports (status, input, and output) and by radio-frequency or video entry to a standard, unmodified color television.*

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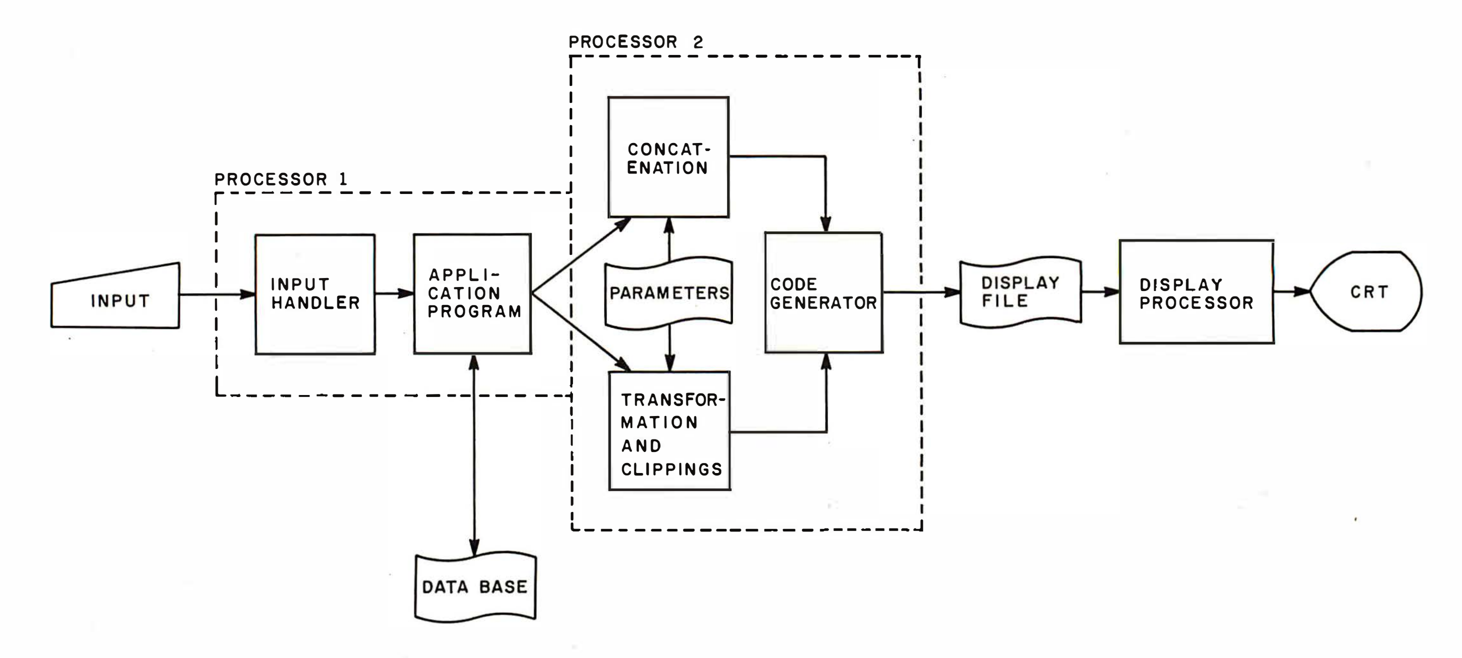


Figure 1: *A general block diagram of an interactive graphics-display system. The functions of Processor 1 and Processor 2 may be performed by the same device; however, the output of Processor 1 must be a structured abstract of the image to be displayed, for the graphics package (Processor 2) to operate. (The figure is from* Principles of Interactive Computer Graphics, *by Newman and Sproull. Copyright 1973, used with permission of McGraw-Hill Book Company.)*

Background on Interactive Computer-Graphics Systems

Newman and Sproull, in their book *Principles of Interactive Computer Graphics* (reference 12), present an excellent model of a generalized interactive graphics system, as reproduced in figure 1. Processor 1, which is not necessarily a different physical processor than Processor 2, handles program-specific processing for a particular graphics application. The output of this processor is generally a structured, abstract representation of the set of images that will be displayed.

Processor 2 represents the processing that is to be handled by a graphics package, as it is commonly called. This processor manipulates the abstract representations, performing transformations (such as rotation, translation, and scaling) and clipping as needed. The output of this processor is generally a display file consisting of instructions that are meaningful to a physical display processor. The display processor uses these instructions to produce an image upon some type of display device. For interactive graphics, these processes must occur very rapidly.

Numerous graphics packages for commercial systems exist to handle the requirements of Processors 1 and 2. SIGGRAPH (Special Interest Group on Computer Graphics) of the ACM (Association for Computing Machinery) has proposed a standard for such systems. However, for our purposes, we must turn our attention to the display processor itself. Before examining the design for a color-

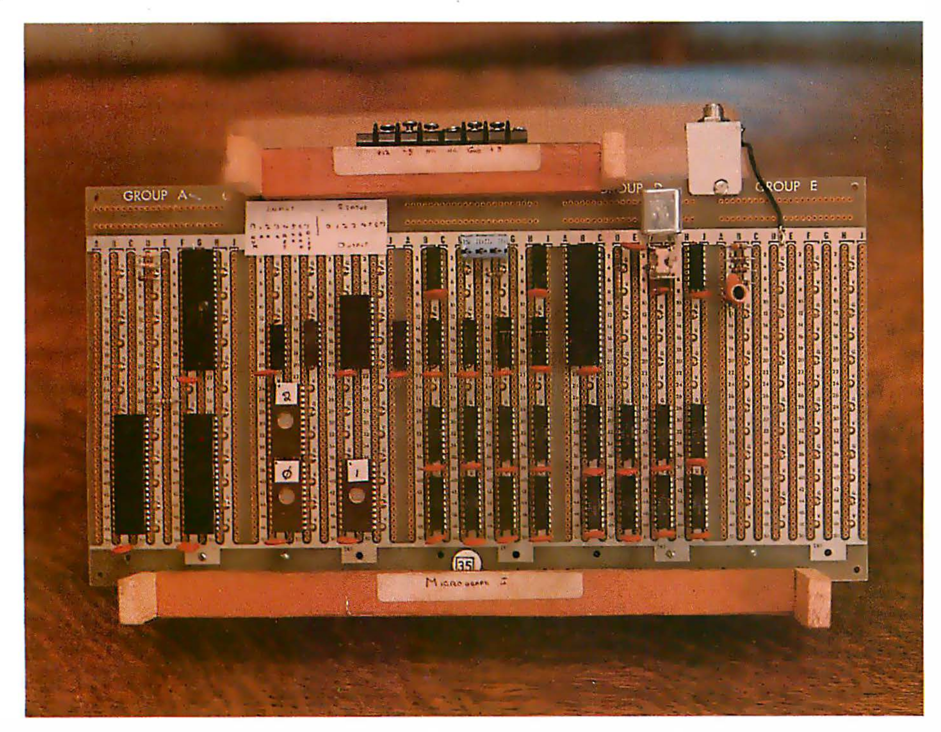


Photo 1: *A view of the completed Micrograph prototype, based on the Motorola MC6847 video-display generator. Use of this integrated circuit greatly simplifies hardware design by eliminating the complex divider-chains usually found in homebrew video displays.*

graphics display processor, we must consider the characteristics of calligraphic and raster-scan displays.

Comparison of Display Devices

Four basic technologies exist to support interactive graphics:

- calligraphic
- raster-scan
- storage-tube
- plasma

Three of these devices (calligraphic, raster-scan, and storage-tube) are CRT-based, but only two (calligraphic and raster-scan) are adaptable to interactive, rapidly moving displays.

Calligraphic displays produce images by drawing vectors using endpoint information. A relative or absolute position is presented to the display, and the electron beam is deflected from its current position. Analog methods of vector generation can produce high-resolution vectors. Symbols are usually generated as a collection of vectors. Special hardware may also exist to produce circles and arcs, but these features are generally not cost-effective.

Calligraphic displays can achieve resolutions of up to 4096 by 4096 pixels (ie: picture elements) which corresponds to 16,777,216 elements (which is why I don't consider 256 by 256 pixels or even 512 by 512 pixels as "high resolution"). (See reference 11.) Therefore, a 21-inch-diagonal rectangular CRT will typically have a spot size of 0.02 inches (0.5 mm). (See reference 9.) Vectors using these techniques will appear sharp rather than granular. Several thousand vectors may be displayed flicker-free.

Calligraphic displays can produce color images using beam-penetration tubes. This type of CRT has multiple layers of phosphor coating on the face of the tube. Individual colors (usually four different colors) are produced by varying the anode voltage and hence the depth of beam penetration.

Raster-scan displays produce an image much like commercial television by generating a full screen of horizontal lines. This set of lines (the raster) is modulated in the Z axis (intensity and color) to produce an image. Vectors are drawn using digital scan-line-conversion techniques which compute every point along the vector. Symbols are usually generated using a character generator which directly plots each point of the symbol.

Raster-scan displays can achieve resolutions up to 2048 by 2048 in monochrome and 1024 by 1024 in color, which corresponds to roughly one million pixels (for color). (See reference 9.) The limited resolution for color displays results from the difficulty in producing shadow masks and the granularity of the phosphor-dot triples used in constructing the CRT. Because of the nature of the raster-scan CRT, the individual dots have insignificant overlap and therefore vectors appear coarse and stair-stepped. However, techniques such as *ordered-dithering* and *anti-aliasing* algorithms exist to reduce the effect of granularity. (See references 7, 10, and 12.) Stair-stepping (or aliasing) is most noticeable in near-

Glossary

Aliasing: *As used here, a granular or stair-stepped appearance in an image caused by the display screen being divided into a finite number of elements. This effect is most noticeable on low-resolution displays and on high-resolution displays with near-horizontal or near-vertical lines.*

Calligraphic Display: *A display that produces an image from a collection of vectors and points, by directing the electron beam in the X and Y directions corresponding to the vector endpoints.*

Display Processor: *A special-purpose peripheral processor that is dedicated to producing a visual image on some type of display (usually a CRT) based on special graphics instructions in a display list.*

Instancing: *The technique of defining one image, then being able to perform transformations to reproduce the same image in several different places on the display.*

Pixel: *A picture element.*

Raster-Scan Display: *A display that produces images, just as in television, by amplitude modulation of the Z-axis beam along a full screen of horizontal lines (the raster).*

Scan-Line Conversion: *An algorithm used to calculate each individual point along a vector, given the starting and ending points.*

Transformation: *Modifications of an image, such as translation (movement in the X, Y, or Z axis), rotation (also in any axis), and scaling (also in any axis).*

CALLIGRAPHIC DISPLAY		RASTER-SCAN DISPLAY	
Advantages	Disadvantages	Advantages	Disadvantages
• High resolution (4096 by 4096).	• Analog circuitry often requires adjustment.	• Digital circuitry is quite reliable.	• Moderate resolution (1024 by 1024 color).
• Thousands of vectors can be displayed.	• Limited colors (usually four).	• Many colors possible (more than 2^{16}).	• Digital scan-line conversion is slow.
	• Display has low brightness.	• Display is high intensity.	
	• Limited intensities are possible.	• Many (gray scale) intensities exist.	
	• Shading of large areas impossible.	• Shading areas is simple.	
	• Flicker occurs when too many vectors are displayed.	• Display does not flicker.	
	• Ghosting occurs on rapidly moving displays.	• Display has high contrast.	

Table 1: *Comparison of calligraphic (ie: vector) and raster-scan displays.*

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Processor Type	Motorola MC68000 Motorola MC6809 for I/O, Disk, and memory management.
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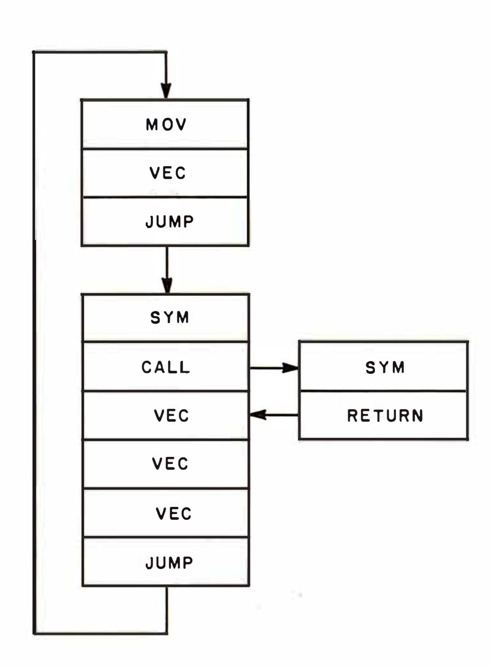


Figure 2: *The display list of primitive instructions performed by the display processor of a calligraphic (ie: vector) display. The loop is performed repeatedly by the processor to guide the display electronics. A new or modified display is produced by altering the display list.*

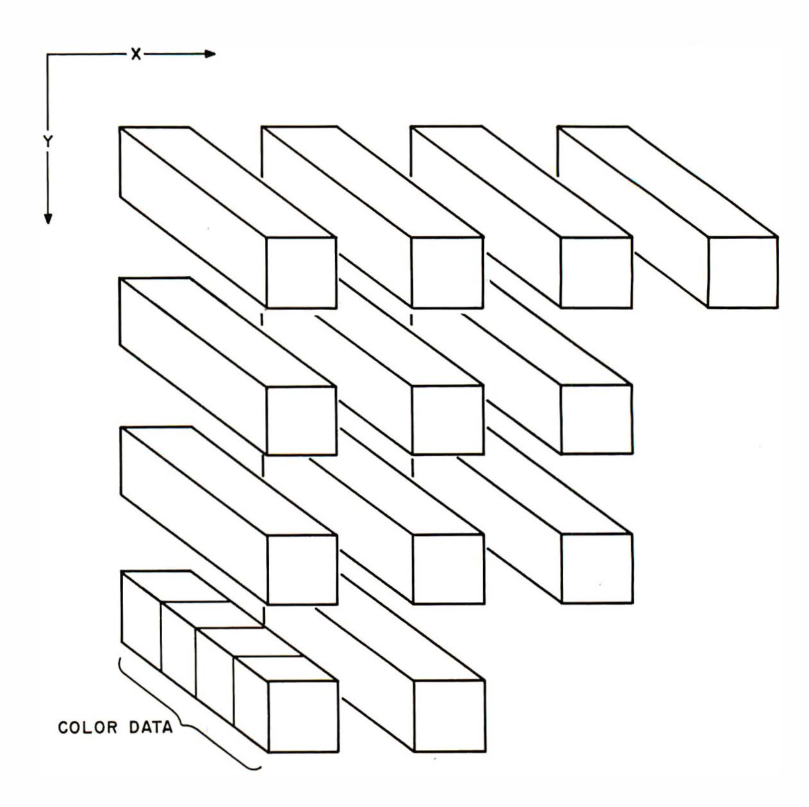


Figure 3: *A color raster-scan frame buffer. Each pixel (ie: picture element) on the screen is represented by a unique set of X and Y coordinates. Every coordinate is associated with some amount of color information (in this case, 4 bits). This data may be used to specify an address in a color-look-up table such as figure 4.*

vertical and near-horizontal lines. Any number of vectors, up to and including a full CRT screen, can be displayed without flicker.

Color raster-scan displays produce their images by exciting triads of dots or rectangles at each pixel. Each triad generally consists of one red, one blue, and one green element. Different colors (in excess of 2^{16}) can be produced by exciting each element at different levels of intensity.

Clearly, the use of each type of display is associated with certain advantages and disadvantages, as summarized in table 1.

Controlling a Calligraphic Display

As mentioned previously, a calligraphic display draws vectors based upon endpoint information. Even the most complex images can be created as a collection of vectors. Because of the short persistence of the CRT phosphors required for a fast calligraphic display, once a vector is drawn, it will disappear very quickly, typically in just a few milliseconds. Thus, the entire display must be continuously refreshed to avoid flicker and a loss of portions of the image. Refresh rates vary with the intensity of the display, but the image must be refreshed at least 30 times per second.

These requirements give rise to a structure called a *display list.* As figure 2 indicates, a display list is simply a collection of primitive instructions for the display processor. The display processor repeatedly scans this list to send vector-drawing information to the display electronics. To modify a display, Processor 2 (of figure 1) simply points the display processor to a new display list, or inserts or deletes a portion of the existing list. Generally, a display list is stored external to the display processor in the host-processor memory and is addressed via DMA (direct memory access).

Numerous instruction sets have been devised for calligraphic-display processors. Since displays at this primitive level are very difficult to control, the trend is toward higher-level graphics languages. However, all primitive instruction sets must contain certain basic features, including primitives to move the beam, draw a line, draw a character, call a subroutine, and change colors or intensity.

Controlling a Raster-Scan Display

Unlike calligraphic displays, raster-scan displays generally employ what is known as a frame buffer. The frame buffer is essentially a block of memory that maintains a one-to-one correspondence with the set of pixels. In other words, there exists one memory location for every pixel. A pixel can be specified in one or more bits, as figure 3 indicates. Thus, color information for a pixel is stored at each memory location. In color raster-scan displays, this memory location does not necessarily hold physical color information, but often supplies a pointer to a color-look-up table, as figure 4 indicates. Thus, for example, a pixel may be specified by 4 bits, but the color information may be translated to any sixteen of a possible 2^{16} colors. This technique allows the display of many different colors with a conservation of memory. The techniques of *contrast stretching* and *pseudocoloring* can be easily achieved with a color-look-up table.

A raster-scan display does require a large amount of memory to implement the frame buffer. For example, a display with a resolution of 512 by

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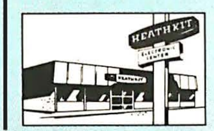
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CP-184

512 by 8 requires 256 K bytes of memory. This drawback is one of the primary reasons that raster-scan devices have only recently become cost-effective.

Using a frame buffer, an image is drawn by inserting color information into the memory location corresponding to the appropriate pixel. This architecture has the feature of producing flicker-free images; however, to draw vectors the display processor must calculate every point along the vector. Scan-line-conversion algorithms that calculate the points of a vector (given the endpoints) exist, but such algorithms are slow compared to analog techniques used in calligraphic displays. Once an image is written into the frame buffer, it will be continuously displayed. Refresh is not required by the host, but the image cannot be modified as a calligraphic display can.

Clearly, the characteristics of color raster-scan displays present control problems unlike those for calligraphic displays. We must therefore not only exploit the inherent color-display potential, but we must also deal with the problems of selectively updating a raster-scan display. As the next section indicates, we can adapt calligraphic control techniques to effectively control a color raster-scan display.

Primitives for a Color Raster-Scan Display

To develop an instruction set for a color-graphics display processor, we must first establish our requirements. We assume as a minimum that these primitive instructions will be executed by an intelligent display processor having both a single-frame buffer and a color-look-up table. Therefore, we require that:

- The set of graphics primitives must permit the construction of any image within the physical limitations of the raster-scan display. The set doesn't need to be minimal: efficiency is a more important characteristic.
- The graphics primitives must be implementation-independent. The primitives must be applicable to any resolution and not be constrained by word size or any similar characteristic of the target processor.
- The graphics primitives must be

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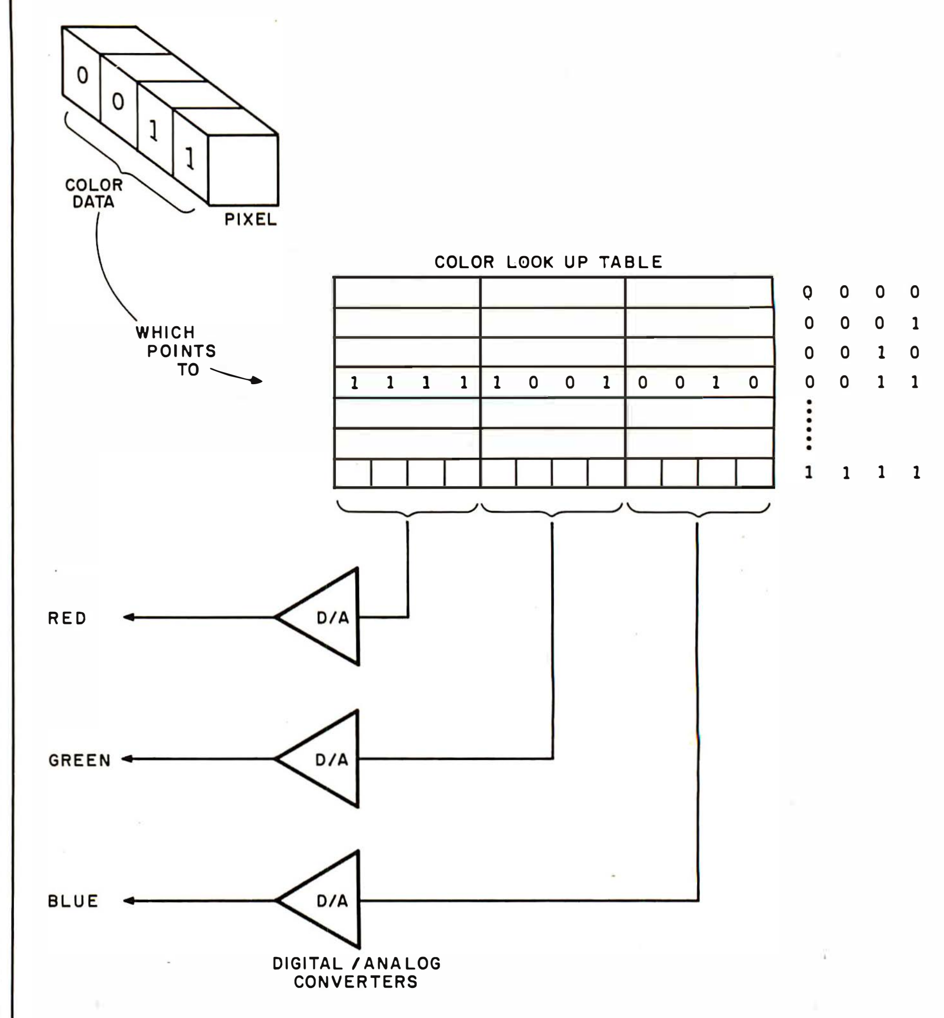


Figure 4: *Color-look-up table. Using this scheme, a 4-bit value from the frame buffer (shown in figure 3) can select one of sixteen predefined colors. In this example, each color is composed of various intensities of red, green, and blue. Other systems may specify colors by indicating values for intensity, hue, and saturation.*

adaptable to a display-list structure, since display lists are a well-established form of control for display processors and hence permit straightforward integration with generalized graphics-support software in the host processor.

Graphics Primitives

As explained previously, we know that raster-scan and calligraphic displays are architecturally different. However, our third requirement indicates that both classes of displays must at least appear identical to the user. Therefore, our graphics primitives become an abstraction for the control of a raster-scan display. We must design a set of primitives independent of the actual architecture of the display. Just as with the benefits of using a high-level programming language, the use of abstractions in controlling a graphics display allows the user to concentrate upon producing images rather than concerning himself with the mechanics of the implementation.

Before examining the primitives for a color raster-scan display, it is important that you understand two very critical abstractions. First, it is necessary that the user visualize the display processor as manipulating a two-dimensional Cartesian surface, with the origin of the space at some predefined location (usually the center, or lower left-hand corner) on the display surface. There may or may not be a direct mapping of pixel data in the display-processor memory to this surface: the actual implementation should be invisible to the user.

From the previous section, we know that the display processor doesn't need to be concerned with identification of objects that are displayed in this space, but rather we

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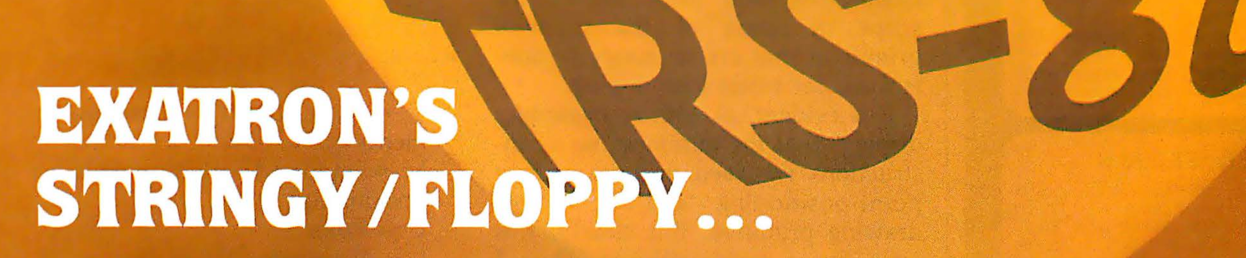


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need only to be able to manipulate the pixel data that forms these objects.

The second abstaction which we must develop concerns *graphics-display registers*. These registers are defined in the display processor and may be addressed by the user to set up global image parameters, such as current vector type, or to provide immediate processor-status information, such as the current X and Y position. Clearly, these registers may be implemented in diverse portions of the display hardware. Concerning the second requirement, it is important that the user sees these registers as an easily addressable set that may be referenced by the host processor. As we shall see, the use of graphics-display registers helps reduce the scope of some of the graphics primitives that are necessary to control a color raster-scan display.

It is evident, as with any graphics display, that the minimum set of instructions we need includes only a point-positioning and a vector-drawing primitive. But clearly, this set is by no means efficient. Thus, I will present and defend the set of graphics primitives for a color raster-scan display which will be implemented in Micrograph. Next I will present the primitive instructions in their mnemonic form in order to maintain their implementation independence.

As with a calligraphic display, one of the most fundamental operations we perform is point positioning. Since a raster-scan display does not produce an image by beam movement, but rather by Z-axis modulation, we must abstract current X and Y coordinates, which may also be addressed as graphics-display registers. To increase the utility of a move primitive (ie: primitive instruction specifying a movement), we must include several options. To begin, both absolute and relative point positioning are necessary. The need for absolute positioning is obvious; relative positioning permits an entire display to be defined relative to a single point in the image, which is an essential feature if subroutines and instancing are to be supported.

Furthermore, remember that the elements of an image are often closely spaced: thus, we need options for long and short movement. With a long movement, we may express a point position in the full-screen coordinates (for either absolute or relative positioning). With a short movement, we may express a point position with a limited maximum value (such as 0 to 7, again either absolute or relative). Therefore, it's possible to decrease display-list memory requirements with the use of short movements, which take less storage than a long instruction. Finally, it is often necessary to simply plot a single point. To do so, we must include the option to illuminate or not. If we illuminate, we obviously must include a parameter for the color of the point. Mnemonically, our move primitive can be represented as:

MOV T,M,C,I,(±)X,(±)Y

where:

T = type (*S*hort or *L*ong movement)
M = mode (*A*bsolute or *R*elative positioning)
C = color
I = illuminate (*Y*es or *N*o)
X = X position or offset (with a sign on the relative mode)
Y = Y position or offset (with a sign on the relative mode)

For example, the primitive:

MOV S,R,4,Y,+3,−4

moves the current X,Y position by an offset of (3, −4) and illuminates that point in a color whose code is 4.

The next obvious primitive we need performs vector drawing. With the same justification as for the move primitive, we must permit the options of long and short vectors. We assume that the starting point of the vector is the current X,Y position, and the endpoints are determined by either absolute or relative positioning. Just as with a move primitive, we must also be able to specify the color of the vector. Finally, we must be able to define the current vector type, such as solid, dashed, or dotted vectors. Experience indicates that such line types are rarely used. Therefore, rather than specifying this parameter in the primitive itself, we assume that we have available a graphics-display register that defines the current line type. Mnemonically, our vector primitive

can be represented as:

VEC T,M,C,(±)X,(±)Y

where:

T = type (*S*hort or *L*ong movement)
M = mode (*R*elative or *A*bsolute endpoints)
C = color
X = X position or offset (with a sign in the relative mode)
Y = Y position or offset (with a sign in the relative mode)

For example, the primitive:

VEC L,A,15,255,180

draws a vector (with the color coded 15) from the current X,Y position to the pixel (255,180).

We must have an instruction that allows us to call a subroutine. Such a primitive is essential to support object instancing. Furthermore, since we assume the existence of an intelligent target display processor, we must expand our primitive to permit a call to a display-processor subroutine. Such an option allows the user to execute his own predefined routines, which can possibly decrease the image-generation time and reduce some of the processing burden from the host for often-used routines. Clearly, this option is not essential, but it does allow the user to exploit the full capabilities of the display processor. Mnemonically, our call primitive (ie: primitive instruction to call a subroutine) can be represented as:

CALL T,N

where:

T = type of subroutine (*P*rocessor or *G*raphics)
N = name or number of subroutine

For example, the primitive:

CALL G7

calls the grapics subroutine number 7.

Along with the call primitive, we obviously must have a primitive which allows us to return from a subroutine. Our return primitive instruction can be represented as:

RET

Text is often an element of a display and therefore warrants its own primitive. It is important to realize that text usually occurs as a string of symbols rather than a single symbol. Therefore, we must include an option to display a number of contiguous symbols. Furthermore, in terms of the symbols themselves, we may wish to use either a standard alphanumeric font or a user-defined font. Therefore, we assume the availability of a programmable symbol generator. As will be explained, the user may define his own set of symbols and then display a string of symbols by using the symbol primitive, passing it the codes for the appropriate symbols. Mnemonically, our symbol primitive can be represented as:

SYM N,$S_0..S_{n-1}$

where:

N = number of symbols in the string
S_i = symbol code

For example, if we have defined a 128-character ASCII (American Standard Code for Information Interchange) set of symbols, the primitive:

SYM 5,68,80,77,80,83

displays the string "COLOR".

Also, as noted earlier, we may need to synchronize our display with the display frame rate, especially if we wish to perform animation with smooth movements. Therefore, we need a primitive that suspends display processing until the end of a frame or until after a certain number of frames. Mnemonically, our wait primitive can be represented as:

WAIT N

where:

N = number of frames to wait

For example, the primitive:

WAIT 7

suspends processing for seven frames.

Since we have assumed the existence of a color-look-up table to facilitate pseudocoloring and contrast-stretching, we must provide some method of controlling such a structure. There are two common methods for the organization of such tables. One method allows for the definition of a color by the proportions of red, green, and blue elements (the colors which physically make up a pixel). This method is easily performed in hardware, but it is not readily adaptable to common English color descriptions (such as hot pink or sea green). A preferred method, which we shall use, defines a color by its hue, intensity, and saturation. This classification refers to, respectively, the gradation of color (red, pink, purple), the brightness of the color, and the purity, or amount of black, in the color (dark red, fire-engine red).

We abstract the existence of a three-part table (which will actually be implemented in hardware) that is used as a color-look-up table. Since this table is user-alterable, we will refer to its parts as *color memories.* (They would usually be implemented as programmable-memory elements.) In order to generalize this primitive, we need to be able to update the entire table, one entire portion of the table (hue, intensity, or saturation), or all the parameters for a given color code. This table will allow selection of 2^n colors out of a 2^{i+h+s} color set where n is the pixel size in bits and i, h, and s are, respectively, the word size of the intensity, hue, and saturation color memory. For example, if $n = i = h = s = 4$, we can select one of sixteen colors out of a 2^{12} color set. Mnemonically, our load-color-memory primitive can be represented as:

LCRAM R,M,(A,)C_i

where:

R = reference (*I*ntensity, *H*ue, or *S*aturation color memory, or *A*ll)
M = mode (*S*ingle address or *A*ll addresses in table)
A = address (optional)
C = color data for the color memory

For example, the primitive:

LCRAM A,S,2,5,7,2

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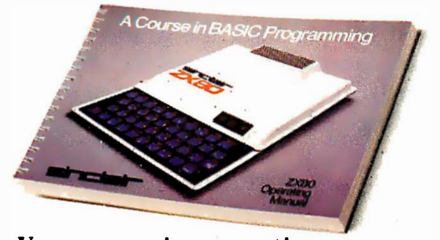
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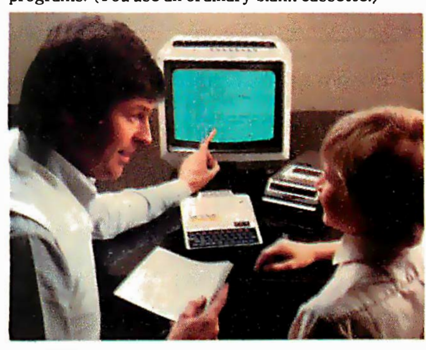
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loads all parameters for the color memories at the indexed color code of 2. The hue, intensity, and saturation are loaded at this address with the data 5, 7, and 2, respectively.

In order to exploit the full capabilities of the frame buffer, we must have some method to access individual elements of the buffer. And we must have the capability of loading all or portions of the frame buffer in order to support selective filling and erasing. If we do not provide this function, it becomes very difficult to produce solid colored or shaded images, which is one of the important advantages of a raster-scan display. Furthermore, if we allow the host to directly load individual elements of the frame buffer, we can produce a full frame that implements algorithms such as *depth queuing* and *shading* that cannot be performed otherwise by the display processor at the pixel level. Thus it is apparent that we do need some sort of load-pixel primitive. In order to increase the utility of this primitive, however, we must introduce the concept of the *viewport.*

Through the graphics-display registers, we can define a rectangular area on the display by a pair of X,Y coordinates (the left and right X boundary and the top and bottom Y boundary). Thus, rather than loading the full screen, we can reference the area bounded by a viewport. This feature permits us to load areas of the display or even to mask portions of the display. To further increase the generality of this primitive, we must also permit loading a single pixel. This feature allows us to change the color of the point we are currently at. We could do the same with the MOV primitive, but this instruction would be shorter. Finally, we can define our load-pixel primitive as:

LPIX R,C_0..C_n

where:

R = reference (*F*ull frame, *V*iewport, or *X,Y*)
C_i = color data

Along with this primitive, we must add that a predefined order of filling the pixels must be maintained, such as left to right, bottom to top. For example, the primitive:

LPIX F,0,0,0,0...

loads the entire display with a single color 0.

The next primitives we need do not actually produce an image, but support the previous primitives. First, since we have assumed the existence of graphics-display registers, we must allow the host to load the registers with a value. In this work, we do not specify the types or numbers of graphics-display registers, since they may vary from system to system. However, certain registers will be consistent, such as vector type and current X and Y position. Mnemonically, our load-register primitive can be represented as:

LREG, N,V

where:

N = register name or number
V = value to be loaded

For example, the primitive:

LREG X,4096

loads the X register with the value 4096.

Since some of these registers contain status information, it is important that the host be able to read back the value in the register. For example, if the display processor supports a light pen, it may be necessary for the host to read back the X and Y position coordinates. Mnemonically, our read-register-primitive can be represented as:

RREG N

where:

N = register name or number

For example, the primitive:

RREG Y

reads the contents of the Y register and returns the value to the host.

Since we have assumed the existence of subroutines, there must be some way of loading subroutines in the display-processor memory: thus we need a load-subroutine primitive. We obviously need the parameters of

Text continued on page 276

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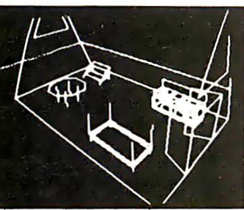
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A Line-Failure Indicator

Hank Olson, POB 339, Menlo Park CA 94025

Have you ever come back from work looking forward to an evening of home computing, only to find that nothing works? The program that was almost debugged during previous evenings is gone?

While nothing short of nonvolatile memory will completely solve this problem, the simple line-failure indicator described here will alert you to problems that occurred while you were away. A simple glance at the three-color display of LEDs (light-emitting diodes) will at least let you know what you are in for. The indicators light as follows:

- green: power is on, no recent failures
- yellow: power has failed and returned
- red: power has been off for a short time
- none: power has been off for a long time

Having different colored LEDs seems best from a human-interface point of view, even though their voltage requirements differ somewhat.

The circuit of the line-status indicator is shown in figure 1. The basic power supply uses a common 6.3 V filament transformer and a bridge rectifier of four 1N4001 diodes. The primary is controlled by SW1, a double-pole switch which prevents the battery from discharging when the unit is off. This supply must provide the current to light one LED plus energize a small relay coil. This represents about 150 ohms, so the RC (resistor/capacitor) time constant of the power-supply filter is about 0.15 seconds. Therefore, if you return to find the yellow indicator on, you will know that there has been a line-voltage dropout of 0.3 seconds or longer.

Looking at figure 1, we see that the green LED is held on by SCR1. The SCR gate can only be triggered into conduction manually by means of SW2. Once this push-button switch (SW2) is (momentarily) closed, a pulse of current enters the gate of the SCR from the 0.1 µF capacitor; and the SCR goes into conduction. Since this SCR operates on DC, it will *stay* in conduction until the DC supply fails (meaning that there is an AC line dropout).

When the DC supply fails, the relay K1 is de-energized, closing the "normally closed" contacts and lighting the

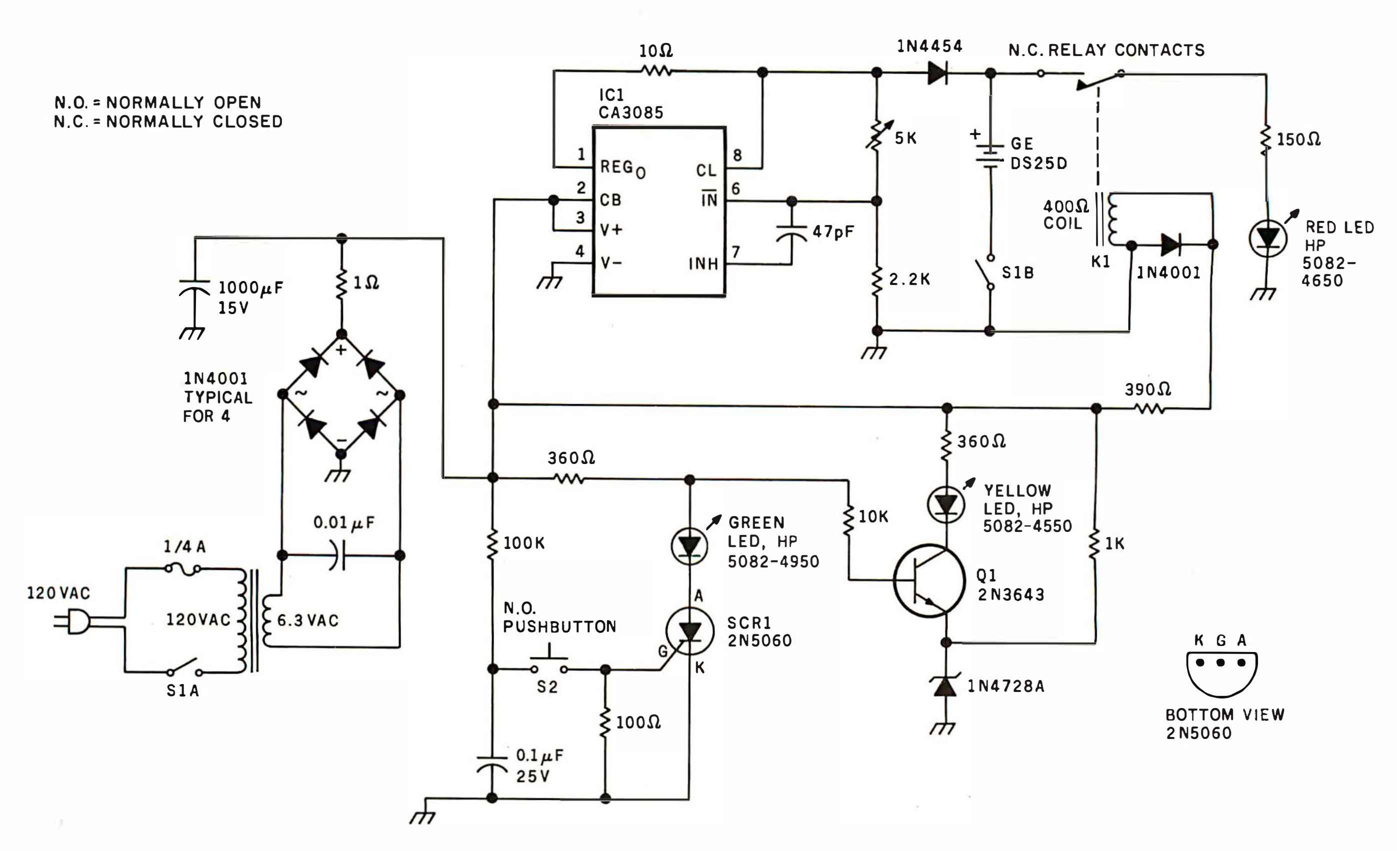


Figure 1: *This power-line-failure indicator uses a silicon-controlled rectifier to detect voltage dropouts. If power should fail for more than 0.3 seconds, the SCR ceases to conduct and the green LED is extinguished, while the red LED lights. The red LED remains on as long as power is out; its power is drawn from a set of rechargeable batteries. Should power return, the red LED goes out and the yellow one is illuminated to indicate this sequence of events.*



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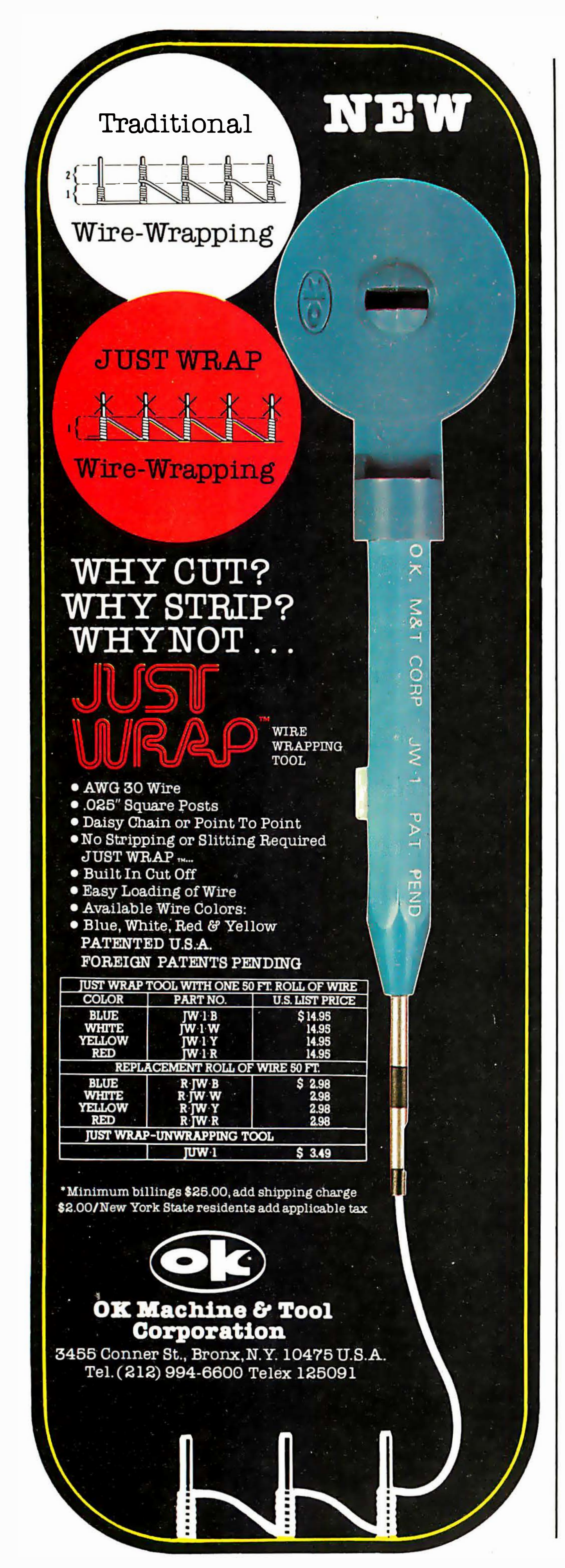
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red LED. The 1N4454 serves to disconnect the two-cell nickel-cadmium (nicad) battery from U1 during power outages, so that the *only* load on the battery is the LED. Use of a relay to actuate the battery-to-LED circuit is the best method, because it closes the circuit with nearly zero resistance, while consuming *no* power in the process. The two-cell nicad, a General Electric DS25D, is a rather small unit made for printed-circuit board mounting and thus fits in easily. This tiny battery will light the red LED for several hours when fully charged.

When AC power returns, DC is quickly restored to energize K1 and to charge the battery via IC1, the regulator. IC1 is a voltage regulator, but it also has current-limit capability. The 10-ohm resistor between pins 1 and 8 of the regulator causes charge current to be limited to 20 mA, even if the battery is nearly discharged. As the battery charges and its terminal voltage approaches the regulated voltage output to which IC1 is set, current drops below 20 mA and tapers off in the "constant-voltage" charge mode.

Meanwhile, the SCR remains nonconducting, which allows current to flow via the 360-ohm and 10 k-ohm resistors to the base of Q1, forward-biasing this transistor and lighting the yellow LED. Thus the yellow LED indicates that power has failed and returned. The red LED has, of course, been extinguished with the energizing of K1.

The final step in the sequence is when the person who uses this line-failure detector notices that the yellow LED is lit, and resets SW2. This act causes SCR1 to conduct, diverting current from the base of Q1, extinguishing the yellow LED and lighting the green LED.

Since it takes between 1.5 and 1.8 V to light an LED, I chose a battery consisiting of two nicad cells in series. This gives a battery voltage of 2.4 V, which is adequate to light LEDs of all colors, using series dropping resistors. Since the battery is charged in series with a 1N4454, the voltage-regulator output should be set (by means of the 5 k-ohm variable resistor) to between +2.9 and +3.1 V. This accounts for the series forward-voltage drop in the 1N4454. Note that an RCA-CA3085 is used as a regulator. An LM305H (National Semiconductor) will not substitute for this integrated circuit since it's not made to regulate below +4.5 V. The older National LM300H would work, however.

K1 can be any small relay having a coil voltage from 4 to 8 V DC, with a set of normally closed contacts. The series resistor is adjusted to drop the unregulated +8 V of the DC supply to the desired voltage of the relay coil. In my own case, a small relay (from an old radiosonde transmitter) which had a 400-ohm coil and which closed reliably on +4 V was used. A 390-ohm resistor was then used to drop the +8 V supply to the coil voltage of +4 V.■

Technical Forum is a feature intended as an interactive dialog on the technology of personal computing. The subject matter is open-ended, and the intent is to foster discussion and communication among readers of BYTE. We ask that all correspondents supply their full names and addresses to be printed with their commentaries. We also ask that correspondents supply their telephone numbers, which will not be printed.

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Language Control Structures for Easy Electronic Visualization

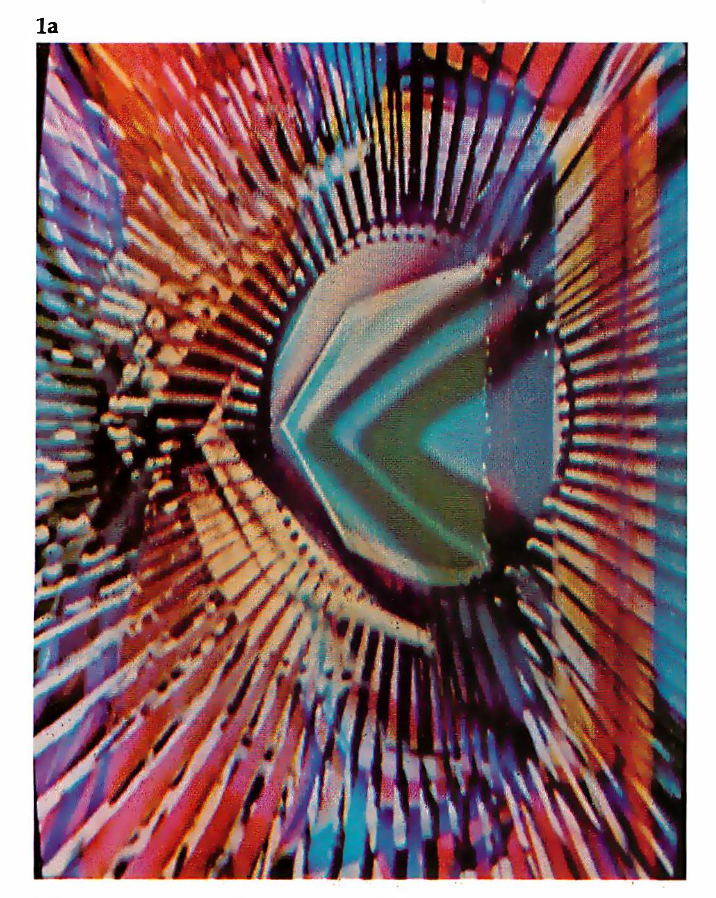
Dr Thomas DeFanti
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Control structures are the program- flow manipulation features of the language that you use to beat your computer into submission. BASIC's control structures are embodied in the RUN, GOTO, GOSUB, and RETURN keywords and a few functions, certainly an impoverished set. Highly structured languages like Pascal are rigidly limited to the control structure of subroutines. Lowly structured approaches like assembly language are necessary to implement higher-level languages and real-time systems, because the lack of enforced structure allows an infinite variety of control structures to be used at a cost of great human effort. The execution-speed gain in using assembly language is more due to the efficient building of customized tables and linked lists than to efficiency in adding, subtracting, multiplying, and dividing numbers.

Assembler coding is by no means easy. Note the word "easy": it's important because in one sense it means *"accessible."* In this case, it's your access to complex electronic visualizations.

Electronic visualizations are important because producing and manipulating images, especially animated ones, is a truly multidimensional task which reflects our real-world interactions much more than maintaining an accurate laundry list or printing payroll checks. Producing them demands a lot from software,

1a



1b



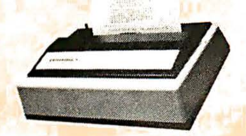
Photos 1a and 1b: *Sample output from the GRASS/Image Processor. Photo 1a was made by Guenther Tetz, and photo 1b by Dan Sandin and the author.*

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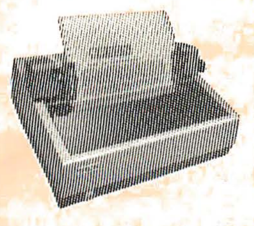
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and making their access easy requires paying attention to the provision of rich control structures in a language.

Electronic Visualization is an intentionally broad term meant to conjure thoughts of computer graphics, animation, image processing, video synthesis, and even advanced word-processing. Anyone successfully producing images for communication is unlikely to reject a technique for reasons of algorithmic purity (as a computer scientist might feel forced to do). Computer hobbyists use the tools at hand, and electronic visualization is the means to the end and the end product of using these tools. Simultaneously, it can be *both* because we are seeing the vast increase of real-time imaging systems, even in microcomputer-based configurations; and controlling these real-time systems can be as feedback-intensive as playing a musical instrument or driving a racing car.

Just to unify the concepts so far, think about this question: what besides the cosmetic packaging governs our choice of a musical instrument or an automobile? It is a combination of capability and user control, of course: having one without the other is useless. So why are the programming languages currently available so impoverished on the control-structure side?

> The most successful approaches to date are basically highly developed, beautifully evolved kluges.

Perhaps it is because computers were invented to process payrolls, not images. Television, on the other hand, is image-oriented and currently uses a host of presently emerging real-time digital techniques and increasingly flexible control structures. As a matter of fact, just about all the television you see these days is digitally processed for purposes of synchronization.

Television is a high-speed medium conducive to parallel and pipeline processing. You are driving television rather than generating it. TV cameras are on all the time and you, as director, are fading, switching, adding titles and constantly throwing away images that you don't want. Control is the name of the game.

The television folk are not about to give up rich, real-time control structures and the computer folk won't give up language. How to get them together is the essence of the task at hand.

Getting Computers and Television Technology Together

Looking at the history of control structures for computer graphics and for television, we see that most computer-graphics usage, with the obvious and exciting exception of video games, is some variety of non-real-time plotting. This is where the money is and where the language development for computer-aided design has been focused. No manufacturer of equipment for computer graphics (excepting the video-game people) now depends on animation for solvency. Plotting is slow and often merely the side output of a large FORTRAN finite-element analysis program. Visual aesthetics are rarely the primary concern, if any concern at all. People who use such systems are highly skilled and highly paid technicians who became that way by having to deal with plotting packages as a condition of employment. If the job were easy, they wouldn't get paid so much.

We are just reaching the point of electronically generating and manipulating images, in real time, under program control. How do we design languages to deal with real time? Or, more important, why do we want such a language, an alphanumeric string-oriented language, at all? Why not use picture-based languages with symbols for motions and timing?

How Can You Control Images Easily?

After about ten years of living with this obvious and nagging question, some conclusions became clear. First, purist approaches to electronic visualization are hopeless. Image control employs a hybrid of languages, several input devices, picture-oriented commands, custom hardware, and a smattering of idiosyncrasies. The most successful approaches to date are basically

highly developed, beautifully evolved kluges. We know what "purism" in coding FORTRAN and BASIC does to image production. Purism in television technique eliminates computer graphics as we know it. So how about using graphic symbols to save the day?

Using symbols in a menu and some sort of manual-selection mechanism is an approach taken by many FORTRAN graphics systems. This limits the number of symbols to those defined in the menu and there is no user-level extensibility in that you cannot create new symbols out of sequences of old symbols, which eliminates the one truly unique feature of computers. To state it bluntly, you can't program with a menu.

What happens, however, if you do find a system that provides for the combination of nonalphanumeric symbols in meaningful ways? In an extremely advanced case, it should look something like Japanese, and you might note that the language used to program computers in Japan is a *phonetic alphanumeric transcription* of their language. They do not program in their extremely beautiful and rich symbol set. Eliminating alphanumeric languages is not such a hot idea, except in turnkey systems.

The second conclusion gestating for the past ten years is that complete parallelism is necessary for controlling images in meaningful ways. You simply must be able to develop sequences independently and merge them in ways that do not necessitate rewriting the programs. Xerox's Smalltalk and certain other languages have this capability, as do television technology and everyday life: making this parallelism easily accessible takes real care.

The third conclusion is that a flexible priority scheme is needed. Some tasks are more important than others, just as in real life and computer operating systems. It is essential to give this capability to the user of an electronic visualization system.

Fourth, providing for user extensibility at several levels is the only way people will easily be able to use a system for applications not envisioned by the designer. I will discuss this later.

Fifth, the system must be software-fault tolerant. Fault-tolerant hardware has been a research area of great importance to real-time control systems, yet language purists still think people should solve problems in structured, orthodox, algorithmic ways. A computer language should provide as many paths to a given communication as possible, as natural languages do, and the kind of error handling that a friend would offer. Allowing nonstructured, nonprocedural, "seat-of-the-pants" programming is often the only salvation when the final goal is aesthetically defined, and is, perhaps, not at all clear. It has been called "fuzzy programming," and it's easy to throw in the recursive, value-returning, clever structured-programming capabilities as well, but limiting yourself to these latter approaches stifles human creativity, problem-solving, and sideways thinking.

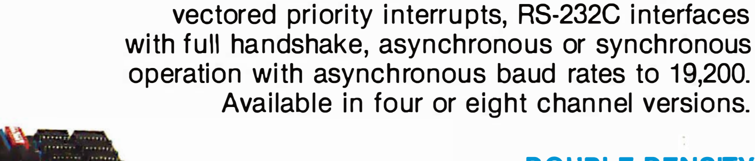
Zgrass — A Language for Easy Electronic Visualization

Zgrass is a programming language and operating system written in assembly language for the Z80 microprocessor by Nola Donato, Jay Fenton, and me. Not surprisingly, it embodies all the control structures mentioned so far in this article and

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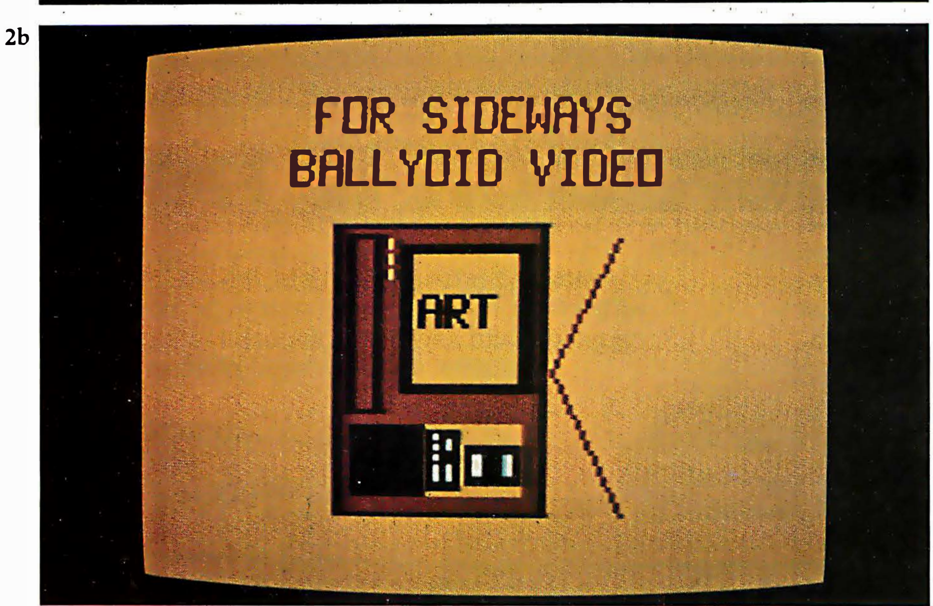


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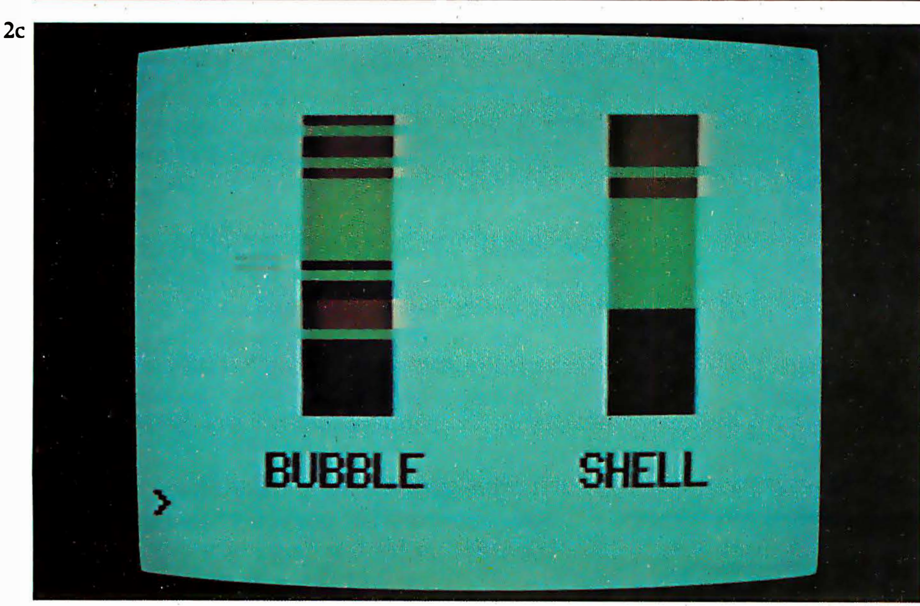
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2a

2b



2c



Photos 2a, 2b, and 2c: *Sample output from the first Zgrass system, with a resolution of 160 by 102 pixels, with 2 bits per pixel. Photo 2a was made by Copper Giloth, and photos 2b and 2c by Nola Donato.*

has been in development for ten years.

Zgrass started out as GRASS (Graphics Symbiosis System), a language designed to bring the immense complexity of a Digital Equipment Corporation PDP-11/45 and as Vector General 3DR Display system within the grasp of artists and educators at Ohio State University. It has high levels of interaction, parallelism, priority, and tree-structured manipulations of vector-defined objects. Photos from this system can be seen in "About the Cover... And Some More of the Same," in the October 1977 BYTE, page 22.

GRASS depends on $120,000 of equipment to run — rather expensive for a single-user system — but it is one of the first highly developed non-FORTRAN interactive graphics systems for use by artists.

In 1973, Dan Sandin, inventor of the Image Processor, brought color television usage to our computer graphics work at the University of Illinois at Chicago Circle. Dan and I developed most of the ideas about control structures presented here. Photos 1a and 1b show some output from the GRASS/Image Processor system.

Generating a complete programming language with parsers, compilers, and graphics takes a lot of human effort. More than ten person-years of programming were devoted to GRASS, aided by generous support from the National Science Foundation, National Endowment for the Arts, and others.

GRASS is totally oriented toward real-time generation and control of images for the simple reason that television cannot easily be slowed down for long and/or time-lapse exposures as can be done with film. The control structures for GRASS were developed ad hoc and became increasingly idiosyncratic. Nola Donato, a postgraduate student of mine, decided to teach me how to generalize many of the programming-language concepts. The result was GRASS3, which later became Zgrass.

In 1977, I was led to Jeff Frederiksen at Dave Nutting Associates, who was developing a deluxe home computer for Bally Corporation using the custom integrated circuits they had developed for the Bally Arcade video game. The pros-

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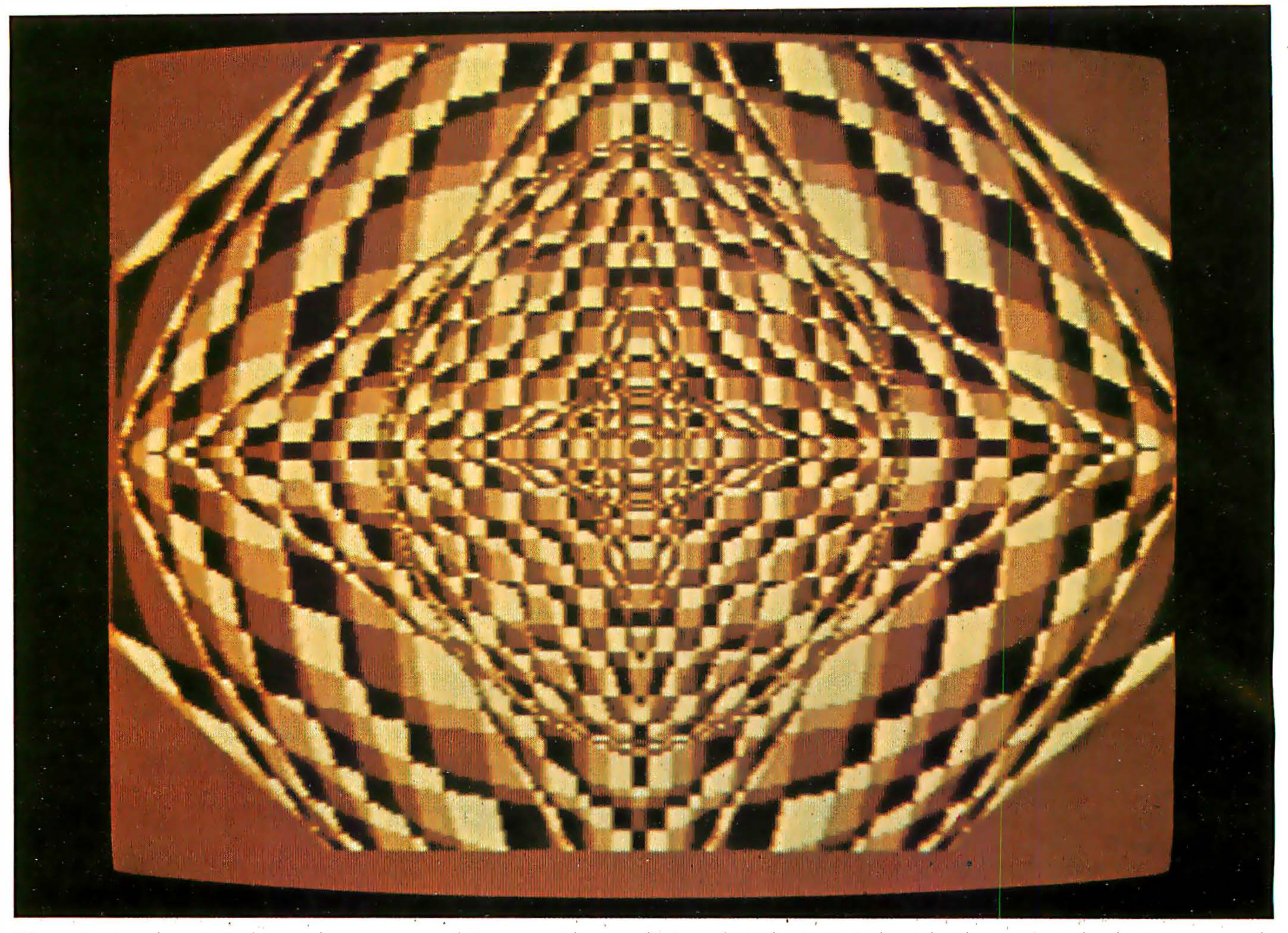


Photo 3: *Sample output from a later version of Zgrass, with a resolution of 320 by 204 pixels with 2 bits per pixel. Photo 3 was made by Frank Dietrich.*

pect of developing a language for fun, one that had user-orientation as the benchmark rather than how many FOR-NEXT loops you could execute per unit time was too good to pass up. I was contracted to produce Zgrass, and in a year, Nola Donato, Jay Fenton (a legendary wizard of video games and pinball-machine operating systems), and I had generated 9000 lines of code. (Much of the work was done not in a lab but in a cabin in the woods of Wisconsin!) Examples of output from this system are seen in photos 2a, 2b, and 2c. Note that the resolution of this first Zgrass machine is 160 by 102 pixels (ie: picture elements), with 2 bits per pixel.

Some confusion arose about whether we were producing a hobbyist machine or a home computer for consumers, so the project was suspended. Even now nobody really knows what a "consumer computer" is supposed to be.

From consulting with less enlightened would-be consumer computer manufacturers, I have perceived that they follow the rather negative view of consumerism. (Few people reading this article would be considered only consumers — I assume that BYTE readers are mostly hobbyists or professionals.) Consumerism is based on great market penetration, and the big question is: "How do you get 90% market penetration like color TV?"

It is also based on consuming, that is, wearing out or getting sick of hardware and software so you go buy more and consume it. The user is expected to supply no creativity, just assume a passive, susceptible-to-entertainment pose — this reminds you of television watching, doesn't it? Well, anything requiring creative energy is akin to hobbyism.

Consumer computers do exist in the form of video games that you can get bored with and buy more — even the advertisements invariably cite the number of new games to be available each month. I don't know how to write a programming language that wears out, though. User-extensibility is planned "nonobsolescence." Zgrass is not a consumer language by current standards.

The project is on active status again, but this time with a hobbyist/professional orientation. We believe there are many people who want a recordable image-producing system for around $3000. The current configuration includes:

- Z80 processor with 16 K bytes of EPROM and 48 K bytes of programmable memory
- custom graphics integrated circuits and floating-point hardware
- dual UARTs (universal asynchronous receiver/transmitters) for connection to larger computers, printers, etc
- RBG (red, blue, green) monitor for best color resolution



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Eight Zgrass units in this configuration have been alive and well and tied into the Bell-Laboratory-developed UNIX operating system since January 1980. Although I have only discussed software design, I must mention that the hardware to test the concepts really exists! See photo 3 and note that the resolution is now 320 by 204 pixels, with 2 bits used per pixel.

Details of Zgrass Control Structures

Programs in Zgrass are called *macros*. Macros are stored as ASCII (American Standard Code for Information Interchange) character strings and normally contain executable Zgrass commands. The fundamental unit of execution in Zgrass is a command, which is either an assignment statement or a function call.

Zgrass does not require declaration of variable types (with the exception of array dimensioning). The software automatically does all conversions that make sense based on the context. Any argument can be a function call whose returned value is converted to whatever is needed, if at all possible. Literals, indirect references, variables, built-in commands, user-defined commands, and user-defined macros are all handled by the same parser, so the syntax is very predictable. The fact that there are no restrictions on name length helps to produce easily read code.

User-Level Extensibility

Extensibility in Zgrass is achieved in two major ways. First, you can write macros which return values, produce graphics, or ask questions; or, through string-manipulation primitives written by Barb Wilson, you can generate other macros. Macros use arguments in exactly the same way as system commands, and are even named and called like system commands.

To reiterate, macros are simply strings of ASCII characters. When a macro is called, an MIB (Macro Invocation Block) is automatically built. It gives information on the invoking function call, the passed-argument list, and pointers to local variables, and provides room for the returned value. MIBs form a stack which implements the subroutining and block structuring of the language. When the macro returns, the MIB is deleted along with the local variables and unused literal arguments, if any, and control is passed back to the caller.

If arguments are to be passed to a macro, they are read by the normal input command, and print statements are suppressed as long as there are arguments left. If no arguments are present or an insufficient number are passed, the print statements function normally and the macro asks for input from the terminal. This allows macros to be used whether or not you know the arguments wanted, with no extra code by the author of the macro.

Macros can also be executed in parallel as background jobs. When called and suffixed by a ".B", the Macro Invocation Block is added to a background linked list. After that, the macro will run forever (it restarts at the beginning when it tries to return) until Control-C or the stop command selectively kills it. Photo 2c shows two sorting algorithms being compared for execution speed in real time, a tricky task in most languages, easy in Zgrass.

The background parallelism is achieved by interleaving execution of the macro statements. The MIB contains all relevant context for execution, including a pointer to the next command to execute, so switching MIBs after each line has been completed is simple and gives the functional parallelism. If there are five background macros, each one gets a line executed, in turn, round-robin fashion. This construct is simple and straightforward with no bizarre side-effects except that unusually time-consuming commands will make the parallelism temporally step somewhat. Background interleaving is easily understood and used even by the most naive users.

Meanwhile, the keyboard is still active. When the user types a command line, it is executed at a higher priority than the background macros. If the user initiates a macro at keyboard level, it will finish before the background macros continue. In any event, the keyboard overrides the background, again in an obvious, predictable way.

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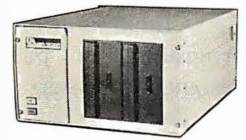
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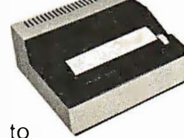


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The user may also specify programs to run as the result of a clock interrupt. When a macro call is suffixed by a ".F", the Macro Invocation Block is chained into a list that is polled every 1/60 second. The user sets the frequency of execution from 1 to 32,768 sixtieths of a second. These foreground macros execute on a higher priority level than the keyboard and background macros so they will start up just about on time (again, delayed only by a time-consuming graphics command). Foreground macros allow a keyboard command to be slipped in during context switching.

Zgrass, then, has three effective levels of priority with parallelism at two of the three levels. Since the Macro Invocation Block maintains all context information, even recursive programming is possible at any level.

One of the severe problems in interpretive, extensible languages like Zgrass is the overhead of parsing and looking up names in name tables. For this reason, Zgrass has a compiler which eliminates the overhead and dramatically increases speed. All the automatic conversions, priority, and parallelism continue to work. Compiling does eliminate some of the interactive debugging features, so you usually debug on the noncompiled version first.

Zgrass System Extensibility

Zgrass also allows extensibility at the system-command level. A system such as this should allow an experienced programmer to write new commands in assembler and interface them to the system easily, certainly without changing the EPROMs (erasable, programmable read-only memories). A transfer vector in low memory and a series of Z80 RST (special restart subroutine-call) instructions allow communication with about one hundred system routines which do parsing, type conversion, graphics primitives, and so on.

Documentation explains what these routines do, and anyone with a cross assembler (or patience for hand assembly) can write new commands of which the system has no prior knowledge. Such extensibility allows virtually infinite variety of specialty graphics commands, device drivers, and so forth to be written and distributed to others on audio tape, disk, or over telephone lines. Terry Disz wrote a debugging program used as a disk-resident command for setting break-points, dumping memory and registers and so on. This capability is not for everyone, but it's there.

The maximum size of one of these user-written nonresident commands is 4 K bytes. Since the typical Zgrass machine has 30 K bytes of programmable memory, the amount of potential custom code is immense. All housekeeping for storage allocation and deletion, maintenance of temporary scratch-pad areas and general cleanup is done by system routines. You only concentrate on the details, obeying a few rules for writing position-independent code.

One further type of extensibility is easy to get. Zgrass has an extra UART which talks to other computers quite nicely. Larger computers can send graphics and character data to your Zgrass machine. Zgrass units can even talk to one another at up to 19.2 k bps!

Error Handling, Debugging and Automated Instruction

Zgrass was designed from the beginning to be a language for writing CAI (computer-aided instruction) programs. In particular, it was designed to be self-teaching to a fairly high degree. When Zgrass is used as a CAI system, the result of providing parallelism, string manipulation, and good error handling is that the student always has the power of the whole language to explore while the author of the CAI programs is also in control.

Since macros are character strings, they can be built and executed. You can take student input, make it into a program (before the student even knows how to edit), let parameters be changed, show the results, and verify certain classes of results both during execution and after. The approaches we have taken to Zgrass CAI are beyond the scope of this article, so I will just mention the system features which make CAI possible.

Error-handling routines normally generate error-message numbers on the terminal. There are about sixty of them and they are quite specific. During regular programming, they are used in conjunction with single stepping, variable printing and other debugging techniques to identify

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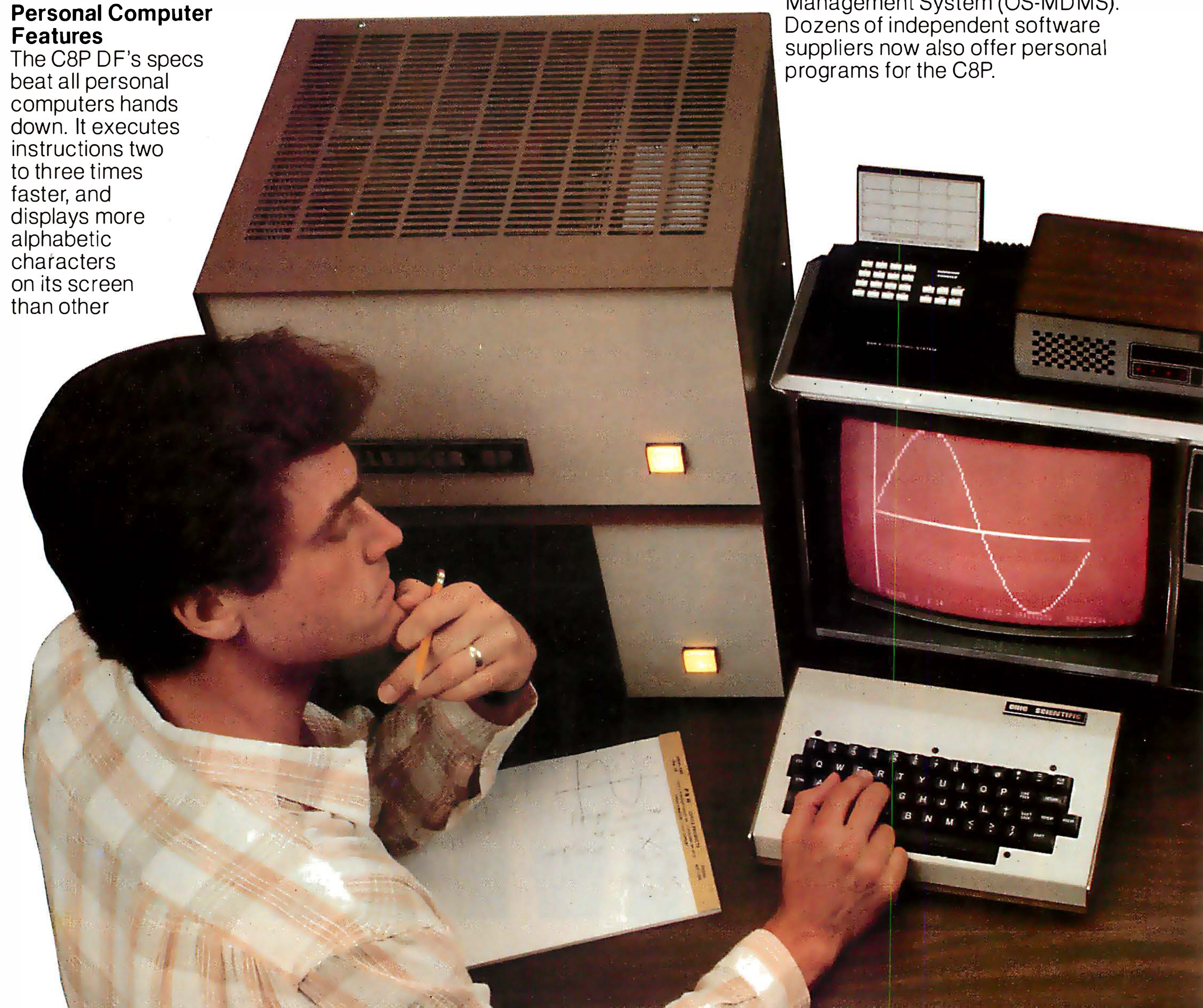
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The C8P DF's specs beat all personal computers hands down. It executes instructions two to three times faster, and displays more alphabetic characters on its screen than other models. It has upper and lower case and graphics in 16 colors. The C8P's *standard* I/O capabilities are far more extensive than any other computer, with joystick and keypad interfaces, sound output, an 8-bit D/A converter, 16 parallel I/O lines, modem and printer interfaces, AC remote control and security monitor interfaces and a universal accessory port that accepts a prom blaster, 12-bit analog I/O module, solderless prototyping board and more.

Ohio Scientific offers a large library of personal applications programs, including exciting action games such as Invaders and Star Trek, sports simulations, games of logic and educational games, personal applications such as biorhythms, calorie counter, home programs such as checking and savings account balancers and a home budgeter just to name a few. A new Plot BASIC makes elaborate animations easy, and music composition program allows you to play complex multi-part music through the computers DAC.

At the systems level the machine comes standard with OS-65D, an advanced disk operating system with Microsoft BASIC and an interactive Assembler Editor. Optional software includes UCSD PASCAL and FORTRAN and an Information Management System (OS-MDMS). Dozens of independent software suppliers now also offer personal programs for the C8P.



puter explorations.

Business Computer Features
The C8P DF utilizes dual 8″ floppy disk drives which store up to eight times as much information as personal computer mini-floppies, and an available double-sided option expands capacity to 1.2 megabytes of on-line storage. The C8P DF is compatible with Ohio Scientific's business computer software, including OS-65U an advanced operating system, and an Information Management System (OS-DMS) with supplementary inventory, accounting, A/R-A/P, payroll, purchasing, estimation, educational grading and financial modeling packages. The system also supports word processing (WP-3) and a fully integrated small business accounting system (OS-AMCAP V1.6). The C8P DF's standard modem and printer ports accept high-speed matrix printers and word-processing printers directly.

Home Control and Industrial Control
The C8P DF has the most advanced home monitoring and control capabilities ever offered in a computer system. It incorporates a real time clock and a unique FOREGROUND/BACKGROUND operating system which allows the computer to function with normal BASIC programs, at the same time it is monitoring external devices. The C8P DF comes standard with an AC remote control interface, which allows it to control a wide range of AC appliances and lights remotely, without wiring, and an interface for home security systems which monitors fire, intrusion, car theft, water levels and freezer temperature, all without messy wiring. In addition, the C8P DF can accept Ohio Scientific's Votrax voice I/O board and/or Ohio Scientific's new universal telephone interface (UTI). The telephone interface connects the computer to any telephone line. The computer system is able to answer calls, initiate calls and communicate via touch-tone signals, voice output or 300 baud modem signals. It can accept and decode touch-tone signals, 300 baud modem signals and record incoming voice messages. These features collectively give the C8P DF capabilities to monitor and control home functions with almost human-like capabilities.

For process control applications, a battery back up calendar clock with automatic computer restart capabilities is available. Ohio Scientific's unique accessory ports allow the connection of a nearly unlimited number of 48 line parallel I/O cards and 12-bit high speed instrumentation quality analog I/O modules to the computer by inexpensive 16-pin ribbon cables.

Exploring New Frontiers
Ohio Scientific's vocalizer software processes normal BASIC print statements with conventional spellings and speaks them clearly in real-time on computers equipped with the UTI (CA-15B or CA-14A). This voice output capability, combined with the C8P's remote control, remote sensing, telephone interface capabilities and reasonable cost open up new frontiers for computer applications.



Documentation
The C8P DF is not a beginner's computer and doesn't come with beginner's documentation. However, Ohio Scientific does offer detailed documentation on the computer which is meaningful for experts, including a Howard Sams produced hardware service manual that includes detailed block diagrams, schematics, parts placement diagrams and parts lists. Ohio Scientific is now also offering fully documented Source Code in machine readable form for OS-65D, the Challenger 8P's operating system allowing experimenters and industrial users to customize the system to their specific applications.

What's Next?
Ohio Scientific is working on a speech recognizer to complement the UTI system, with a several hundred word vocabulary. The company is also developing an 8 megabyte low-cost, add-on hard disk for use in conjunction with natural language parsing to further advance the state-of-the-art in small computers. The modular bus architecture of the C8P assures system owners of being able to make use of these new developments as they become available just as the owner of a 1976 vintage Challenger can directly plug in voice output, the UTI and other current state-of-the-art OSI products.

The C8P DF with dual 8″ floppies, BASIC and two operating systems costs about $3000, only slightly more than you would pay for a dual mini-floppy equipped personal computer with only a fraction of the capabilities of the C8P.

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problems. When teaching, however, the CAI program must trap errors. These fall into three types: syntax, nontermination, and logic.

To trap syntax errors, you should use the ONERROR command which transfers the control to a diagnostic section of the program that you, as a CAI author, will have provided. There you can get the error number, the erroneous argument, and even the entire ASCII text of the line in error with the GETERROR command. You can then explain the problem to the user in whatever level of detail you wish.

Indefinite loops are caught with the LOOPMAX command which sets a limit to the number of control transfers (ie: skips and GOTOs). Once the limit is exceeded, an error is generated and trapped as explained earlier. So, you can catch nonterminating programs or be very meticulous and require efficiency from advanced students by lowering the LOOPMAX appropriately.

Logic errors are trickier and the general case is impossible. However, if you choose suitable problems to solve, you can do some very nice verification. For graphic tasks, the CMPARA command can check a student's building of an image against a prototype. The CAI author can tell if the student's image is a proper subset of the prototype and let it continue. Once a stray pixel is written, CMPARA returns a value of −2 which means the image is "mixed up," and you inform the student immediately. This approach clearly falls short of genuine artificial intelligence, but it is nevertheless quite useful. Several classes at the University of Illinois at Chicago Circle have been taught with great success using a GRASS-coded prototype (called GAIN, by Tom Towle).

Conclusions

Zgrass is a language/system designed to provide easy access to computer graphics and, in general, to computing. It has sophisticated real-time structures and control capability, and it's friendly, extensible, and fun. The language is more efficient than BASIC, more user-oriented than FORTRAN or Pascal, and it has the kind of language-control structures that will help you create your mind's fantastic visualizations on your video screen with more ease than ever before. ■

Glossary

Color: *The 256 colors available in Zgrass form an abbreviated spectrum. You can get four colors on the screen at any one time. The default colors are white, red, green, and blue. They are also known as color 0, color 1, color 2, and color 3. The values are stored in $L0, $L1, $L2, and $L3 unless you modify $HB to use the right-side colors $R0, $R1, $R2, and $R3.*

Color Map: *The color map is the way Zgrass translates color 0 thru color 3 to the 256 available colors. The hardware looks at the values of $L0 thru $L3 before it writes a pixel to the screen. If it is writing a 0, it uses the color stored in $L0; if it is writing a 1, it uses the color stored in $L1, and so on. To change the color map so 1 refers to yellow instead of red, set $L1 to 127. There are actually two color maps, the $Ls and the $Rs. You get to the $Rs by setting $HB.*

Color Option: *The possible values for color option are 0 thru 15. You may need to study your truth tables for inclusive-OR and exclusive-OR (XOR) logical operations to really understand what's going on. The following is functionally true, however:*

Color Option	Meaning
0	*replace with color 0 (white)*
1	*replace with color 1 (red)*
2	*replace with color 2 (green)*
3	*replace with color 3 (blue)*
4	*don't draw (actually XOR with 00)*
5	*XOR screen with color 1 (01 binary)*
6	*XOR screen with color 2 (10 binary)*
7	*XOR screen with color 3 (11 binary)*
8	*change red to white, blue to green (clear bit 0)*
9	*change green to white, blue to red (clear bit 1)*
10	*OR with 01 (if red or white, stay red; if blue or green, stay blue)*
11	*OR with 10 (if green or white, stay green; if red or blue, stay blue)*
12	*replace with red only if white were there*
13	*replace with green only if white or red were there*
14	*increment the color there by 1 (white to red, red to green, green to blue, and blue to white)*
15	*decrement the color there by 1 (white to blue, red to white, green to red, and blue to green)*

Macro: *A string that is supposed to contain legal Zgrass commands. Most programming languages call such things "programs" or "subroutines," but we call them macros. Macros are effectively user-defined commands. Macros can behave just like commands in the sense that you can pass arguments to macros with the INPUT command and return values with the RETURN command. You define a macro just like you define a string, with an assignment to a name or by using EDIT.*

String: *A collection of characters (ie: numbers, letters, punctuation) delimited (ie: enclosed) by single or double quotes or balanced (ie: enclosed) by brackets or braces. If you have to use a string delimiter in a string, make sure that it is delimited by a different string delimiter or things will get very confused. Most likely it will consider the rest of your macro as part of the string. Examples:*

```
"THIS IS A LONGER STRING"
"PRINT A*B*C
SKIP  -1  ;.THIS STRING
COULD BE A MACRO TOO"
[THIS IS HOW TO PUT A
QUOTE IN A STRING: " ' "]
[1234]
[ ]
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Book Reviews

Applied Mathematical Physics With Programmable Pocket Calculators

by Robert M Eisberg
McGraw-Hill Book Company, New York NY, 1976
176 pages, softcover
$9.95

This book by Professor Eisberg of the University of California, Santa Barbara is interesting on three counts. First, it introduces the reader to numerical methods for differentiation, integration, and solution of differential equations. Second, these methods are applied to the general problems of mathematical physics, starting with the motion of an oscillator and finishing with Schrödinger's equation. Third, the programs for the solution of the equations in these fields are given for the Hewlett-Packard HP-25 and the Texas Instruments SR-56 calculators.

A reader's first reaction might be that the programs apply only to the solution of the problems of mathematical physics. However, the mathematical procedures that were aimed at these calculators may also be applied to any computer. Furthermore, the problems are in the field of physics, but the methods of solution of these problems should be of interest to the general reader.

This book discusses the derivative and methods of obtaining it, followed by programs and examples. Problems for testing the program are also given. Procedures for integration and summation are introduced with the appropriate programs and examples for solution.

The numerical procedure for the solution of second-order differential equations is developed without the great depth required for mathematical development. These equations are given for both undamped and damped motion, as well as the driven oscillator. The program development and the results obtained are interesting.

The harmonic oscillator section is followed by the coupled oscillator. The examples for the coupled oscillators and their motion are interesting not only for the study of the motion of such systems, but also for the solution of the simultaneous equations involved.

The concept of central force motion is introduced, including orbital path determination. This section concludes with alpha particle scatter due to repulsive forces. A "random" number generator program is introduced and applied to problems of entropy, or run-down evaluation.

Finally, Schrödinger's time-independent equation is introduced and evaluated, and programs are given for the harmonic oscillator and the potential well.

This is an admirable little book on mathematics applied to physics and the programming of such material for the HP-25 and SR-56 programmable calculators. It is also of great interest to the computer programmer because of the procedures discussed, which are adaptable to the computer.

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The Little LISPer

by Daniel P Friedman
Science Research Associates Inc
Palo Alto CA, 1974

58 pages, softcover
$3.95

It might seem a little odd to review a six-year-old book, but there is a good reason for it in this case: LISP has only recently become available for microcomputers. John Allen (guest editor of the August 1979 BYTE special issue on LISP) has promised that his LISP Company will unveil a full line of LISP systems. It will start with a Z80 version and proceed to much more capable LISPs for the new 16-bit microprocessors. Also, LISP interpreters from other sources exist for Z80, 6800, and AM-100 processors.

The next question is how does one learn LISP? Reference manuals give too much detail and not enough feel for the language. Most introductory material gives too little detail and not enough feel for the language, and nearly all books on LISP make the mistake of telling the student what LISP functions are and what they do instead of how to use them. There is an alternative to all this. One can obtain *The Little LISPer*, study it for a short time, and come away with a firm grasp of the essentials of LISP. This grasp is sufficient to make sense out of the rest of the material concerning LISP and LISP-based systems that one might encounter.

The Little LISPer was originally written to provide a two-week course for nonprogrammers.It is one of the best introductions to any language that I have ever read. I went straight through it the day I got it. The sequence of topics (interleaving functions, data structures, programming principles, recursive programming techniques) is laid out with a deft touch that has the student progressing much faster than he realizes. This organization of the material allows the reader to build up a sophisticated sense of the patterns inherent in LISP structures almost without noticing.

Other features that contribute to the relaxed, but speedy, progress of the student are the organization of the entire text into carefully constructed sets of questions and answers and the light humorous touch of the examples.

LISP operates on list structures, and most of the data used in the book are lists of foods. One of the problems for the reader is to determine the list that results from inserting the atom ROAST after the atom CHUCK in a list beginning:

(HOW (MUCH WOOD). . .

Unfortunately the text breaks off too soon, leaving the reader with a clear sense of things he was just about ready to do, but will have to find out about elsewhere. In any case, the author says the reader is "better prepared than he realizes" to learn the details of a full LISP system and many more advanced programming techniques. It is only necessary to become familiar with the full range of features of a complete LISP system before diving into the world of artificial intelligence and numerous other fields.

LISP is a realization and extension (in notation, not computing power) of Church's lambda calculus, one of the most powerful mathematical tools in existence. It is generally considered a remarkable achievement to teach a powerful mathematical technique to nonmathematicians. As far as I am concerned, though, this kind of teaching should be normal, and the usual "math is hard and you're too dumb to learn it" approach should be thrown away. The fact is that most people are not too dumb to learn mathematics of whatever sort, but few people are clever enough to learn improperly presented mathematics. It seems that even fewer are clever enough to present it well. I am delighted to have an opportunity to point out an instance of top-quality textbook writing and to offer my congratulations to Daniel Friedman.

Mokurai Cherlin
APL Business Consultants Inc
POB 1131
Mt Shasta CA 96067

Mathematical Elements for Computer Graphics

by David Rogers and J Alan Adams
McGraw-Hill Book Company, New York NY, 1976
Softcover, 239 pages
$12.95

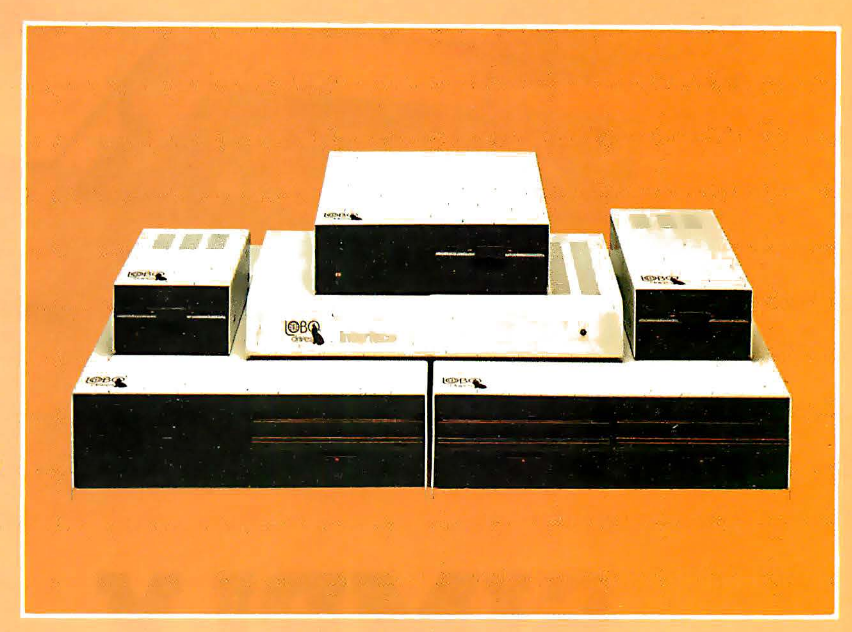
One of the ironies of computer graphics is that it is the aspect of computer use that most attracts people who do not like mathematics, while it is one of the few fields of computing (contrary to popular belief) that require mathematics. *Mathematical Elements for Computer Grapics* is a good sourcebook of the mathematics, the formulae, and the algorithms required to implement graphics packages and applications on computers of any size. It is especially well suited to personal-computer use, since all of the algorithms are presented in BASIC.

Rogers and Adams assume several things about the reader. First, they assume that the reader is writing, or wants to write, software for a line-drawing display (such as those produced by Tektronix). If you have a television-technology display (like most small-computer users), you will need to devise the software to make it draw lines. They also assume that the reader has a substantial background in mathematics. Unfortunately for this subject, a substantial mathematical background means three terms of college-level calculus plus matrix algebra. Also, the algorithms are presented in Dartmouth BASIC, which requires a fair amount of conversion before it will

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work in Microsoft BASIC or BASIC-E.

For those of you who have not yet been scared off, you will learn algorithms and techniques for: scaling, rotation, curve representation, three-dimensional displays, three-dimensional transformation, and surface description and display. Of course, I am only summarizing; Rogers and Adams break these topics down into 65 sections, plus algorithms.

So why buy (or borrow) this book ? If you want a text to teach yourself computer graphics, this is the wrong book. It will not really tell you how to put all of the algorithms together into a usable package or application. But, if you already know something about computer graphics and need a reference to give or compare formulae and algorithms, then this is definitely the right book. A caveat is in order: I have not checked any of the algorithms or programs for typographical accuracy. Which is to say, it's a good reference, but not a good text.■

John A Lehman
716 Hutchins #2
Ann Arbor MI 48103



Duplicated NAND Gate

A drafting error marred Steve Ciarcia's article "A Build-It-Yourself Modem for Under $50" (August 1980 BYTE, page 22). The pin numbers for a section of an integrated circuit were incorrectly marked, duplicating the numbers for a different section.

In figure 1b on page 28, the NAND gate of IC4c should have had its input indicated as being on pins 8 and 9, with output on pin 10. The pin numbers for IC4d are correct as shown.■

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Books Received

The following is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgement of these books and the publishers who sent them.

Bit-Slice Microprocessor Design, Jim Brick and John Mick; McGraw-Hill Book Company, New York NY 1980; 7¾ by 9½ inches (20 by 24.5 cm), 398 pages, hardcover, ISBN 0-07-041781-4, $18.50.

Computer Peripherals for Minicomputers, Microprocessors, and Personal Computers, C Louis Hohenstein; McGraw-Hill Book Company, New York NY 1980; 6 by 9 inches (15.5 by 23 cm), 312 pages, hardcover, ISBN 0-07-029451-8, $19.50.

Early British Computers, Simon Lavington; Digital Press, Bedford MA 1980; 5¾ by 8¼ inches (15 by 21 cm), 130 pages, softcover, ISBN 0-932376-08-8, $8.

A Guide to Structured COBOL with Efficiency Techniques and Special Algorithms, Pacifico A Lim; Van Nostrand Reinhold, New York NY 1980; 6 by 9 inches (15.5 by 23 cm); 272 pages, hardcover, ISBN 0-442-24585-8, $18.95.

Master Handbook of Electronic Tables & Formulas, third edition, Martin Clifford; Tab Books, Blue Ridge Summit PA 1980; 6 by 8¼ inches (15.5 by 21 cm), 313 pages, softcover, ISBN 0-8306-1225-4, $8.95.

More Chess and Computers: The Microcomputer Revolution, The Challenging Match, David Levy, Monroe Newborn; Computer Science Press, Potomac MD 1980; 5¼ by 8⅜ inches (13.5 by 20.5 cm), 117 pages; softcover, ISBN 0-914894-07-2, $12.95.

Practical Area Navigation, Paul Garrison; Tab Books, Blue Ridge Summit PA 1980; 6 by 9¼ inches (15.5 by 23 cm), 224 pages; softcover, ISBN 0-8306-2286-1, $5.95.

Practical BASIC Programs, Lon Poole; Osborne/McGraw-Hill, Berkeley CA 1980; 8⅜ by 10⅞ inches (20.5 by 26.6 cm), 171 pages, softcover, ISBN 0-931988-38-1, $15.

Project Whirlwind: The History of a Pioneer Computer, Kent C Redmond and Thomas M Smith; Digital Press, Bedford MA 1980; 7⅝ by 9½ inches (18.6 by 24.5 cm), 280 pages, hardcover, ISBN 0-932376-09-6, $21.

Some Common BASIC Programs, third edition, Mary Borchers and Lon Poole; Osborne/McGraw-Hill, Berkeley CA 1980; 8⅜ by 10¾ inches (20.5 by 27.5 cm), 195 pages; softcover, ISBN 0-931988-06-3.

Structured BASIC and Beyond, Wayne Amsbury; Computer Science Press, Potomac MD 1980; 6 by 9 inches (15.5 by 23 cm), 310 pages, softcover, ISBN 0-914894-16-1, $10.95. ■

BYTE's Bugs

The First Shall Be Last

The Washington Area Computer Society (WACS) meets on the *last* Friday of the month (not the first) on the campus of the Catholic University of America in Washington, DC, in the first-floor lecture room in Keane Hall, starting at 7:30 PM. Incorrect information about the meeting time had been published in a past issue of BYTE. ■



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Complex Number Subroutines

William R Harlow, Department of Mechanical and Industrial Engineering, 836 Rhodes Hall, University of Cincinnati, Cincinnati OH 45221

I teach numerical methods to engineering students at the University of Cincinnati, where we have an Amdahl computer. Also, various departments have purchased Heath, IMSAI, Radio Shack, and Wang systems. Although the big system has built-in hardware to perform complex operations, the smaller systems must have them implemented as subroutines.

Besides the four fundamental operations of addition, subtraction, multiplication, and division, there are several important functions of a complex variable. These include log(z), e^z, sin(z), cos(z), z^p, and others. Since addition and subtraction are so easy to handle, they are not included in the routines listed here.

Listing 1 gives a set of BASIC routines to do the complex operations listed in table 1. Other functions not

Listing 1: *Subroutines for manipulation of complex numbers. See table 1 for a description of the functions calculated. Note that some of the routines use the constant #PI, which should be set to 3.1415926535.*

```
1000 REM
1010 M1=A1*A2-B1*B2:M2=A1*B2+A2*B1:RETURN
2000 REM
2010 D=A2↑2+B2↑2
2020 Q1=(A1*A2+B1*B2)/D:Q2=(A2*B1-A1*B2)/D:RETURN
3000 REM
3010 R=SQR(A1↑2+B1↑2):I=SGN(A1)+3*SGN(B1)+4
3020 ON I GOTO 3050,3060,3070,3110,3080,3090,3100,3060
3030 B=ARCTAN(B1/A1)-#PI:GOTO 3120
3050 B=(-#PI/2):GOTO 3120
3060 B=ARCTAN(B1/A1):GOTO 3120
3070 B=#PI:GOTO 3120
3080 B=0:GOTO 3120
3090 B=#PI+ARCTAN(B1/A1):GOTO 3120
3100 B=#PI/2:GOTO 3120
3110 P1,P2=0:GOTO 3120
3120 R0=P*LOG(R):R=EXP(R0)
3130 P1=R*COS(P*B):P2=R*SIN(P*B):RETURN
4000 REM
4010 I=SGN(A1)+3*SGN(B1)+4
4020 IF I=4 THEN 4120
4030 L=.5*LOG(A1↑2+B1↑2)
4040 ON I GOTO 4060,4070,4080,4120,4090,4100,4110,4070
4050 L2=ARCTAN(B1/A1)-#PI:GOTO 4130
4060 L2=(-#PI/2):GOTO 4130
4070 L2=ARCTAN(B1/A1):GOTO 4130
4080 L2=(#PI):GOTO 4130
4090 L2=0:GOTO 4130
4100 L2=#PI+ARCTAN(B1/A1):GOTO 4130
4110 L2=#PI/2:GOTO 4130
4120 PRINT "LOG(Z) IS UNDEFINED":STOP :RETURN
4130 L1=L:RETURN
5000 REM
5010 E1=EXP(A1)*COS(B1):E2=EXP(A1)*SIN(B1):RETURN
6000 REM
6010 U1=(EXP(B1)-EXP(-B1))/2:U2=(EXP(B1)+EXP(-B1))/2
6020 S1=SIN(A1)*U2:S2=COS(A1)*U1:RETURN
7000 REM
7010 U1=(EXP(B1)-EXP(-B1))/2:U2=(EXP(B1)+EXP(-B1))/2
7020 C1=COS(A1)*U2:C2=SIN(A1)*(-U1):RETURN
8000 REM
8010 IF B1<>0 THEN 8050
8020 IF A1<0 THEN 8040
8030 R1=SQR(A1):R2=0:RETURN
8040 R1=0:R2=SQR(-A1):RETURN
8050 R=SQR(A1↑2+B1↑2)
8060 R1=SQR((R+A1)/2):R2=SGN(B1)*SQR((R-A1)/2):RETURN
```

Line Number	Operation type	Input; Use	Other Variables Used	Output
1000	product $z_1 \times z_2$	A1,B1;A2,B2		M1,M2
2000	quotient z_1 / z_2	A1,B1;A2,B2	D	Q1,Q2
3000	power z^p	A1,B1	P,R,I,B	P1,P2
4000	natural logarithm Ln z	A1,B1	I,L	L1,L2
5000	exponential e^z	A1,B1		E1,E2
6000	sine sin z	A1,B1	U1,U2	S1,S2
7000	cosine cos z	A1,B1	U1,U2	C1,C2
8000	square root $z^{1/2}$	A1,B1	R	R1,R2

Table 1: *Table of complex number operations performed by subroutines in listing 1. In the "Input" column (A1, B1) refers to the complex number A1+B1i, where i is the square root of −1. In the "Output" column, the two numbers listed are the real and imaginary parts of the answer; eg: the output variables M1 and M2 of the multiplication routine mean that the result of the multiplication is the complex number M1+M2i.*

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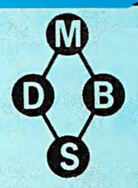
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included could be the hyperbolic and inverse trigonometric functions. The square root of a complex number was included even though it is a special case of z^p. The only complicated ones are the power and the logarithm. This is due to the angle utilized.

The subroutines have been given large line numbers so that they may be put at the end of a program. Users can certainly renumber these lines or use only those needed for a particular problem.

Two rather simple problems (see listings 2 and 3) are included to demonstrate the use of the functions. Both make use of Newton's method to solve for the roots of a function. This is done using the following iterative formula to obtain a better approximation of z, z_{k+1}, from the current approximation, z_k:

$$z_{k+1} = z_k - f(z_k)/f'(z_k) \text{ where } k=1,2,\ldots$$

An initial or starting value of z is selected ($z=x+iy$). Thus $z_1 = x_1 + iy_1$ is used in $f(z_1)$ and $f'(z_1)$. This will generate a z_2 which is fed back into the right-hand side of the equation to give a z_3, and so on.

The method is rapid in convergence and quite stable. If a certain z_k should make $f'(z_k)$ very small or zero, however, it is best to restart with a new z_1. In the programs shown, a test to stop cycling is made on the $f(z)$:

```
IF SQR(F1↑2+F2↑2) <1E-6 THEN . . .
```

This statement stops the iteration when the complex error has a magnitude of less than 10^{-6}. ■

Listing 2: *Example program using the subroutines of listing 1. The program given in listing 2a attempts to find a root of the function* $f(z)=e^z - z^2$. *Note that its derivative* $f'(z)=g(z)=e^z-2z$. *Listing 2b shows two separate runs of the program with starting points of (1,1) and (−1,0); the final results are underlined. Due to the cyclic nature of* e^z, *there are an infinite number of solutions to this problem.*

(2a)

```
10 INPUT "                              KEY IN X,Y ",X,Y
12 PRINT
15 PRINT TAB(14);X,Y
20 A1=X:B1=Y
30 GOSUB 5000
40 P=2
50 GOSUB 3000
60 F1=E1-P1:F2=E2-P2
65 IF SQR(F1↑2+F2↑2)<1E-6 THEN 120
70 G1=E1-2*A1:G2=E2-2*B1
80A1=F1:B1=F2:A2=G1:B2=G2
90 GOSUB 2000
100 X=X-Q1:Y=Y-Q2
110 GOTO 15
120 STOP "              ROOT DETERMINED. KEY RUN FOR A NEW SET"
```

(2b)

```
X1 =  1                  Y1 = 1
      2.912389622375      2.575157181739
      2.187132232955      2.174648753578
      1.760811047732      1.808824533853
      1.603663701734      1.596954184978
      1.58722527008       1.54253028231
      1.588042823737      1.540223443863
      1.588047264669      1.540223501065
      --------------      --------------

X1 = -1                  Y1 =  0
     -.733043605249         0
     -.7038077863239        0
     -.7034674683272        0
     ---------------        -
```

Listing 3: *Example program using the subroutines of listing 1. The program given in listing 3a attempts to find a root of the function* $f(z)=2z^2 + (-6 - i)z + (20 - i) = (2z + 4 - i)(z - 5)$. *(Its roots are* $(-2 + 0.5i)$ *and 5.) The derivative* $f'(z)=g(z)=4z + (-6 - i)$. *Two runs of the program are shown in listing 3b, with the final results underlined.*

(3a)

```
10 INPUT "                              KEY IN X,Y ",X,Y
12 PRINT
15 PRINT TAB(14);X,Y
20 A1=X:B1=Y
40 P=2
50 GOSUB 3000
60 F1=2*P1:F2=2*P2
70 A2=-6:B2=-1
80 GOSUB 1000
90 F1=F1+M1-20:F2=F2+M2+5
95 IF SQR(F1↑2+F2↑2)<1E-6 THEN 200
100 G1=4*A1-6:G2=4*B1-1
110 A1=F1:B1=F2:A2=G1:B2=G2
120 GOSUB 2000
130 X=X-Q1:Y=Y-Q2
140 GOTO 15
200 STOP            "ROOT DETERMINED. KEY RUN FOR A NEW SET"
```

(3b)

```
X1 =  1                  Y1 = 1
     -3.307692307727     -4.461538461515
     -1.45941644561      -1.379310344755
     -1.434942737807       .532192367931
     -2.053130882705       .488693591 7174
     -2.00036624035        .4998063289297
     -2.00000001228        .4999999788526
     --------------        --------------

X1 =  2                  Y1 =  2
      2.207547169882     -2.226415094319
      2.830440251643      1.193459119487
      4.902563504007     -1.877088064073
      4.604564248345     -.193451138577
      5.015324400454      2.68292464E-02
      4.999923902019      1.12126002E-04
      4.99999999917 7    -2.49665620E-09
      --------------     --------------
```

BYTE's Bits

International Systems and Courseware Exchange

One of the greatest deterrents facing organizations that desire to purchase a microcomputer is the fact that the development of systems applications software is costly and time-consuming. In an attempt to find a solution to this situation, John Earle Associates Inc has met with educators, professionals, and business people to discuss means for alleviating this problem. These discussions culminated in the establishment of the International Systems and Courseware Exchange (ISCE). The purposes of the ISCE are to enable schools, businesses, and professionals to license others to use their proprietary courseware and systems for an annual fee on a lease basis, and to recover the developmental costs of the software through the licensing fee. All schools, governmental agencies, doctors, lawyers, engineers, accountants, businesses, manufacturers, and freelance developers of systems applications, courseware, or games are welcome to participate, as providers or as users; or as is the case within many businesses and schools, they may be included in both categories.

A free catalog will be provided to each individual or organization with listings in the catalog. Catalogs will be available to others for $10.

The first catalog containing listings of software and all information necessary to order or submit programs will be published in January, 1981. Catalog entries dealing with administrative or business applications should be mailed to Howard R Baldwin, Registrar, University of Akron, 3220 Miles NW, Canton OH 44718. Catalog entries concerning educational or professional applications should be sent to Swen A Larsen, Dean of Science and Technology, World University, Barbosa esq Guayama, Hato Rey, Puerto Rico 00917. For a copy of the catalog or for more information, contact John Earle Associates Inc, POB 12213, Loiza Station, Santurce, Puerto Rico 00914.

Pass the Salt and the Computer, Please

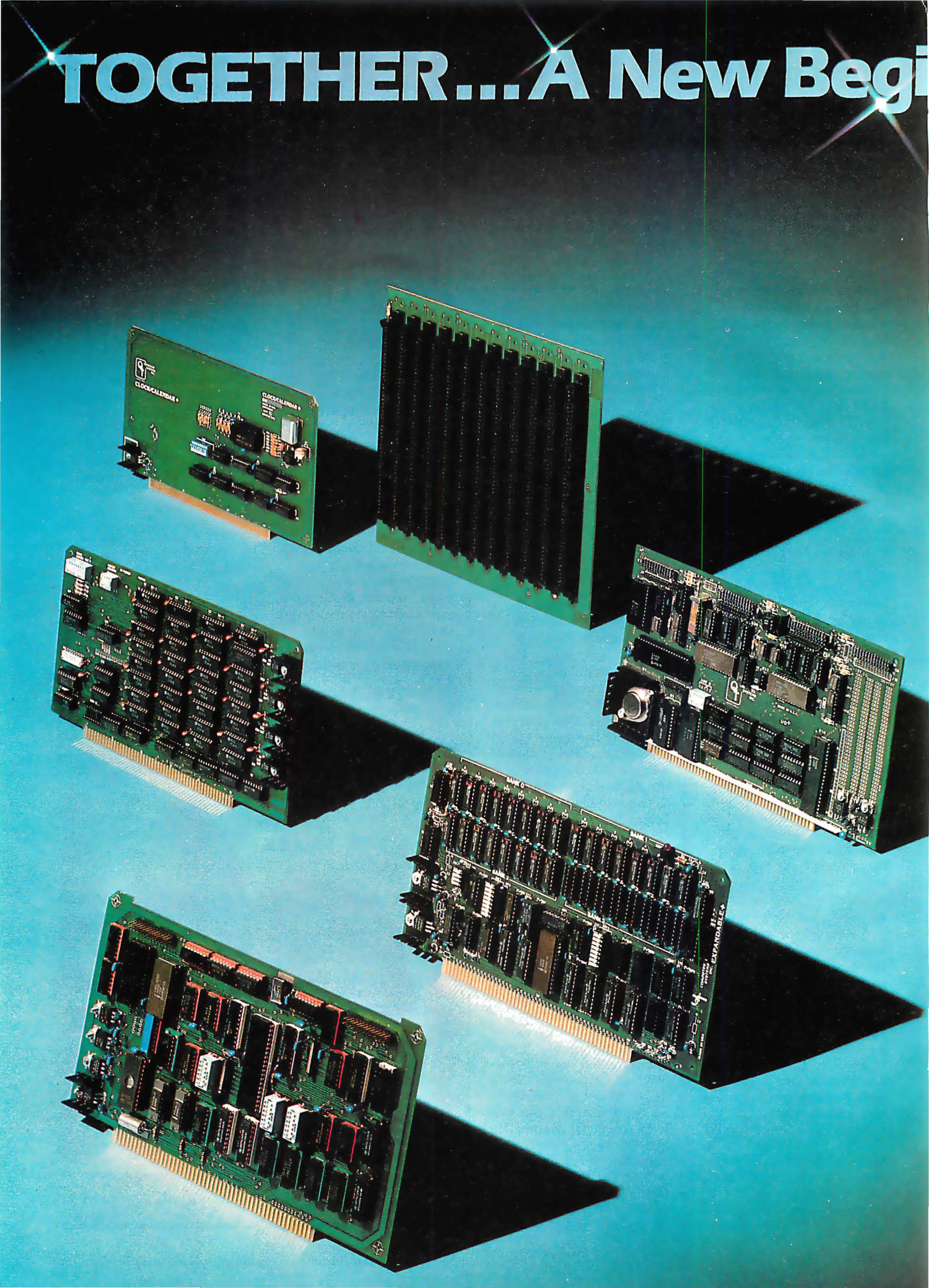
Eleven of the nation's newspapers affiliated with the AP (Associated Press) are experimenting with electronic delivery of news to the home. Through the joint efforts of the newspapers, the AP, and CompuServe Inc, an information networking firm, a daily electronic edition will be published for at least six months. The results of this test will be shared with the 1300 daily newspapers and 3500 radio and television stations that are a part of the AP news cooperative.

The newspapers participating are *The Columbus Dispatch*; *The Washington Post*; *Los Angeles Times*; *The New York Times*; *Chicago Sun-Times*; *The St Louis Post-Dispatch*; *The Minneapolis Star* and *Tribune*; *The Atlanta Journal* and *Constitution*; *The Norfolk Virginian-Pilot* and *Ledger-Star*; *San Francisco Chronicle*; and *The Middlesex News* (Framingham, Massachusetts). Each newspaper contributes news items and computing expertise to produce the news that is delivered to the CompuServe computers. Customers with a terminal and modem merely have to place a telephone call to link up with the electronic editions. Home users are charged $5 per hour, billed in 1-minute increments. The service operates from 6 PM to 5 AM weekdays and all day on weekends and holidays.

The experimenters hope that the test will provide substantial information on marketing the service, promotion, design of the data base, and new sources of advertising revenue. For more information, contact CompuServe Inc, 5000 Arlington Centre Blvd, Columbus OH 43220, (614) 457-8600.

Tuition-Free Program for Women in Electrical Engineering

A brochure from the University of Dayton outlines a National Science Foundation-sponsored Fast-Track program for women interested in electrical engineering. To qualify, an applicant must hold a bachelor's degree in mathematics, physics, or a related science. Participants earn a certificate that serves to advance them to an academic level equivalent to that of an electrical engineering graduate. Credits earned can be applied toward a bachelor's degree in electrical engineering. A Fast-Track staff at the university offers counseling and guidance, assists in part-time work placement, arranges for partial living expense stipends and placement in engineering jobs at program conclusion. The program commences January 5, 1981, and lasts thru December 19, 1981. Copies of the brochure, entitled *Women Interested in Engineering*, can be obtained by writing or calling Carol M Shaw, Assistant Dean, School of Engineering, University of Dayton, Dayton OH 45469, (513) 229-2736. ■

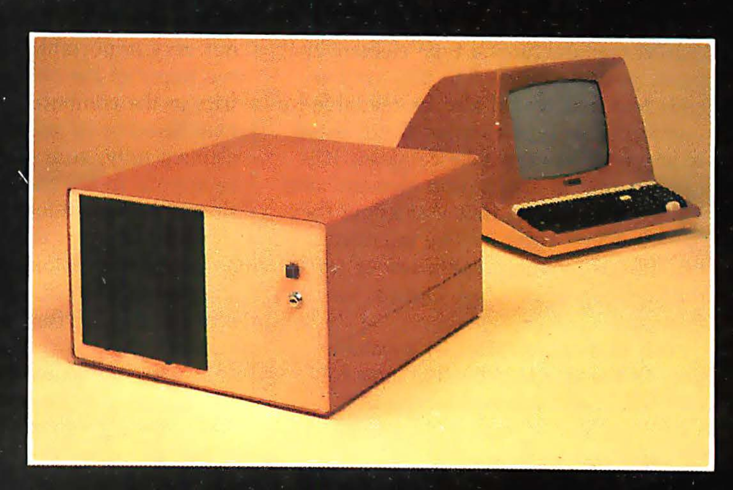

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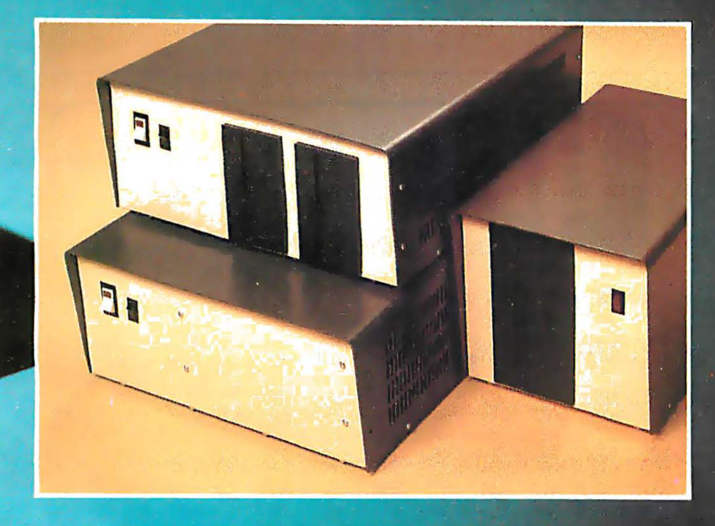
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Letters continued from page 20:

Impressive Bar-Code Maker

IBM manufactures a type element that could possibly be used to prepare bar-code text that would also be readable by humans. This type element is *not* listed in any of IBM's typeface catalogs. It is called a special-application element, and I guess IBM figures that you know they have it if you want it. The intended application is for the preparation of text for input on a Dataflow Optical Reading System.

This element is currently available only in the standard 88-character format. IBM sales representatives in Michigan could not find out if it was going to be manufactured in the new 96-character format too. This point is not very important, since there are not too many of the new 96-character Selectrics in the computer-users' market. The new Selectric III will use the 96-character element only, so it won't be of much use to anyone in the market to upgrade, since they would lose their investment in the type elements they had.

The element is called *DF-2 OCR* and the part number is 1167659. IBM's current price is $18 for one element, or $16 each for three or more.

IBM recommends that you use a Tech III ribbon (IBM number 1136391) with the DF-2 OCR element; the High-Yield Correctable Film carbon ribbon just doesn't make an adequate impression all the time. The DF-2 OCR is a 10-pitch element, by the way, so don't order it unless you have 10-pitch capacity. I would be interested in hearing from any readers who interface the HEDS-3000 to their computer and use this element to generate the input data.

Michael Essig
POB 828
Jackson MI 49204

Figure 1: *An example of the IBM DF-2 OCR output, using the High-Yield Correctable Film Ribbon.*

The IBM DF-2 Type element is a unique optical character recognition type face combining conventional characters with a bar-code to meet the requirements of the DATAFLOW Optical Reading System. IBM recommends the use of their TECH III ribbon to obtain the highest print quality.

ABCDEFGHIJKLMNOPQRSTUVWXYZ ><#$%Δ&*()°+ :';□ '!?,./

abcdefghijklmnopqrstuvwxyz 1234567890

BYTE's BOMB Cards

*From the first year of BYTE to the present we have put great stock in your monthly comments that accompany BOMB (BYTE's Ongoing Monitor Box) cards. We really do read every one of them, and we are often influenced by your comments. What follows is a representative sampling from the cards over the past few issues. By the way, if you'd like to add your votes on this month's articles to our tally, simply fill out the BOMB card at the back of the magazine, using the article table on the second-to-last page as a guide....***CM**

Pournelle:

- *The User's Column* is a very good idea—keep on!
- Pournelle is great!
- More Pournelle please. I'm subscribing.
- Very interesting theme. No more Pournelle, please.
- [Pournelle wrote the] best article on TRS-80 since BYTE began.
- Are Pournelle's articles only to be semiregular? I vote for more.
- Pournelle alone will get me to subscribe.
- Pournelle has no finesse.
- Pournelle helped me decide between Radio Shack, Apple, and Atari... TRS-80 and Omikron here I come.
- Jerry Pournelle's column told me far more about TRS-80 add-ons than I have managed to learn in many weeks of searching.

Ciarcia:

- Mr Ciarcia has done it again.
- Don't lose Steve, he's worth his weight in gold!
- You should put two or three more Steve Ciarcias on the payroll.
- Ciarcia's article was excellent, but only Bo Derek gets a 10.

CAI:

- [I was] glad to have some really good info on CAI!
- There were too many articles on CAI.
- CAI makes as much sense as substituting computer-game playing for physical education. Education is achieved through dint of personal dedication and mental application of effort. Chrome-plated push-button gee-gaws cannot substitute for same.

Others:

- Excellent editorial.
- The editorial by Dr Braun rated a ten.
- Editorials should be rated.
- Your product description of the Apple III was terrific—and they say regular magazines can't get new products published quickly.
- I found the product description of the Apple III outstanding.
- Not being so good at hardware and "systems stuff," I found the July issue more readable than usual.
- Surprisingly, the standard of the July issue was exceptionally low.
- After I finish this BOMB card, I'm going to fill out the subscription form.
- The quality of articles in BYTE is slowly going downhill.
- [July was the] best overall issue of BYTE in a while!
- [July was] a rather dull issue—let's keep it on a professional level.
- Indeed you *are* starting to speak English instead of "highbrow."

How About...

- More hardware!
- More language-oriented articles!
- More homebrew articles!
- More on 16-bit processors!
- Emphasis on personal applications?
- Less educational material—more technical articles?
- Publishing "Favorite Benchmarks" as they come in.
- Publishing information about the Signetics 2650 microprocessor?

Coming up:

- I would like to see articles on homebrew graphics terminals.
- I would appreciate more articles on the new 16- and 32-bit microprocessors.
- I would very much like to see in-depth articles on speech recognition.
- When will you publish more articles on artificial intelligence?
- It would be nice if more articles could appear on fantasy games....

CP/M Vendors?

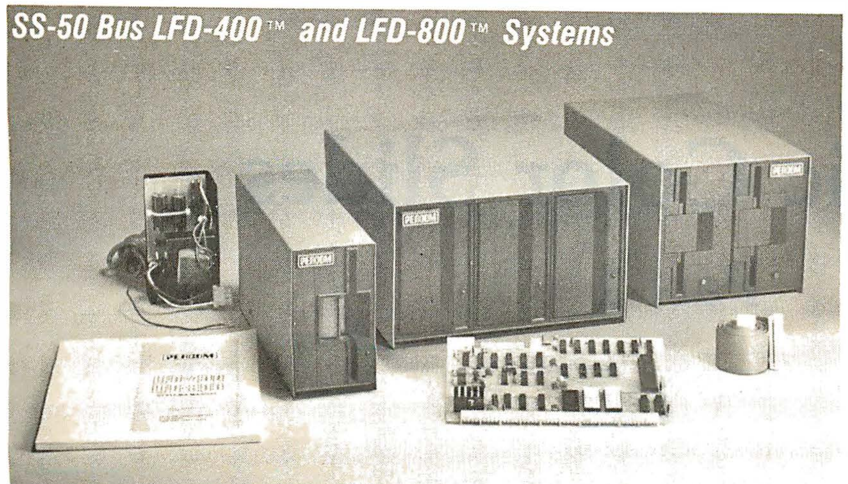
As the developers of CP/M and MP/M, we at Digital Research are preparing a list of vendors of CP/M-compatible software. We would appreciate the help of BYTE readers in compiling this list for distribution to all interested persons who contact us.

If you are currently marketing CP/M-compatible software, please send us any or all literature pertaining to your software. If you have any questions, please contact Curt Geske, at Digital Research, POB 579, Pacific Grove CA 93950, or (408) 649-3896.

Thank you.

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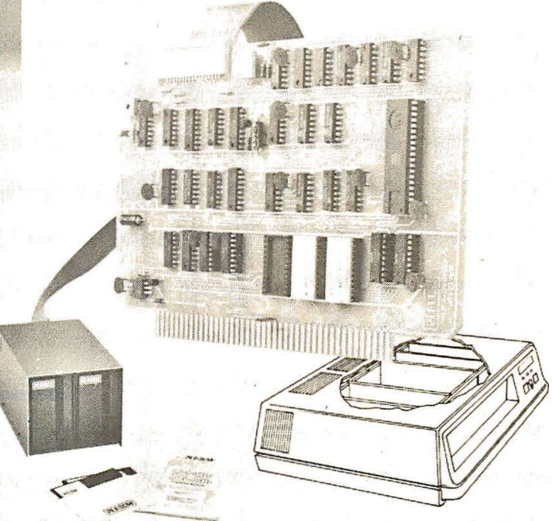
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MOTHERBOARD — accommodates five SS-50 bus cards, and may itself be plugged into an SS-50 bus. Features wide-trace conductors. Price: $21.95

SS-50 BUS CARD — accommodates 34- and 50-pin ribbon connectors on top edge, 10-pin Molex connector on side edge. Price: $24.95.

SS-30 BUS CARD — 1¼-inch higher than SWTP I/O card, accommodates 34-pin ribbon connector and 12-pin Molex connector on top edge. Price: $14.95.

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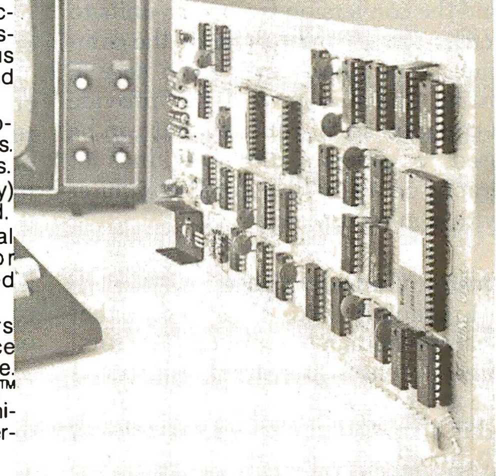
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Graphic Color Slides

Part 1

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Color slides of graphs, bar charts, and other visual aids are a valuable addition to various public presentations. When made using conventional methods, the slides are expensive to produce and difficult to modify. But when the slide is produced by photographing a computer-generated color image (as described in my article, "Making Color Slides with an Intecolor Microcomputer," January 1980 BYTE, page 20), the slide can be produced inexpensively and the image can be modified easily. Points, lines, bars, and curves can be drawn to represent numeric data.

Unfortunately, writing the program that creates the screen image can be tedious and time-consuming. Many aspects of the program design, such as the selection of suitable scales and the conversion from user-units to screen-units, can be done by the computer. The subroutines given here in listing 1 have been written to provide a common set of routines that can be used to generate different kinds of graphs on a Compucolor II computer with a minimum of effort.

Design Considerations

Ergonomic texts (ie: those that analyze human engineering factors) suggest that scales are most convenient for the user if they are subdivided in steps that are powers of ten—1, 10, 100, 0.1, 0.001, etc. Double- and half-size steps (2 and 0.5) are also acceptable for intermediate ranges, although other scale intervals (such as 0.75, 1.5, 3, 4) should be avoided. Based on this, I have written

> Writing the program that creates the screen image can be tedious and time-consuming.

subroutines to select a suitable step size from the series: 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50....

The ideal number of steps depends upon the application. On graph paper, where fine measurements may be made, a large number of smaller steps is useful. On a video monitor or in a color slide, however, a smaller number of large steps is preferable because it is less confusing; around four to eight steps seem to be appropriate. The scale should start and end at a multiple of the step size.

A program that satisfies these criteria should be easy to write; some readers might want to stop at this point and write their own. Unfortunately, there are several pitfalls for the unwary. At several stages of the calculation and graph preparation, it is necessary to avoid calculation errors (for example, producing 2.99999 or 3.00001 instead of 3). Similarly, scale zero might be calculated as 1.000E-06, which looks odd if printed on a graph scale.

The first step of the scaling process is to calculate the range of the data, R, and make an initial guess for the value of the step size, JUMP. This value can be obtained from table 1, or it can be calculated from the following equation:

```
JUMP = 4 * 10↑(INT(0.434295
         *LOG(R/1.21)))
```

(This is essentially line 10315 of the BASIC program in listing 1; the constant 0.434295 is used to obtain the base-10 logarithm from the Compucolor BASIC LOG function, which returns the natural or base-e logarithm.)

Once the initial value of JUMP has been calculated, it is repeatedly divided by 2 until the resulting value for JUMP is less than or equal to one-fourth the value of the range R; this assures that the graph will have at least four steps in the range. The constant 1.21 is chosen to give the relationship between R and JUMP shown in table 1.

Implementation Notes

The program has been written, tested, and employed to illustrate this article on a Compucolor II. The BASIC interpreter recognizes two-letter variable names but tolerates longer names (ie: AXIS, AXES and AX are all equivalent). Names were chosen to avoid BASIC reserved words such as INT, OR, ON, STEP. Thus the variable COLOR has been spelled COLOUR, and JUMP has been used in place of STEP. For graphics work this version of the language employs the word PLOT followed by one or more arguments. Table 2 lists the more important plotting codes.

Text continued on page 138

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HOW DID WE DO IT?

The secret of SuperBrain QD's incredible disk storage lies within our new double-density double-sided disk drives. A total of nearly 720,000 bytes of data are formatted on two specially designed 5¼" drives. And that's more than enough to get you started with most serious small business applications. And SuperBrain QD's standard 64K of dynamic RAM will handle even the most complicated programming tasks.

Of course, if you're into megabytes instead of kilobytes, you may think neither SuperBrain is right for you. Not so! Intertec offers 20-96 megabytes of hard-disk storage which connects in seconds to either the SuperBrain or SuperBrain QD. So, your original investment is always protected. As you grow. No matter how much your needs expand.

BUT IS IT RELIABLE?

Our best salesmen are our present users. Not only have SuperBrain users been impressed with the inherent reliability of the system, they tell us that no other microcomputer system available today offers such a unique modular design concept. Just about the only tool required to easily maintain the system is a common screwdriver. And Intertec's total commitment to product service and customer support, with service outlets in most major cities, insures your original investment will be a valuable one for many years to come.

THE DECISION IS YOURS.

Whether your next SuperBrain is a regular model or our QD version, you will have the satisfaction of knowing you purchased what is becoming one of the world's most popular microcomputer systems. And regardless of which model you choose, you'll probably never outgrow it because you can keep expanding it.

So, call or write us today for more information. Intertec systems are distributed worldwide and may be available in your area now.

Circle 80 on inquiry card.



2300 Broad River Rd., Columbia, SC 29210
(803) 798-9100 TWX: 810-666-2115



*Registered trademark of Digital Research, Inc.

Listing 1: *Collection of plotting subroutines and driver program for the Compucolor II. See text and listing remarks for further description of the subroutines.*

```
5 REM KY 5 REM      GRAPHS.  (C)  A. W. GROGONO.  AUG.  1979
6 REM      SUBROUTINES V1
40 RESTORE :CLEAR 200:DIM I$(12)
50 DATA 1, 2, 6, 4:FOR I= 1TO 4:READ COLOUR(I):NEXT I
60 REM WRITE:  60 DIM(ARRAY(25, 1))  TO USE EQUATION SUB
90 PLOT 29, 27, 24, 15, 14, 2, 255, 6, 1, 12, 3, 16, 3:REM CLEAR PAGE
100 REM
101 REM
110 REM  SUBROUTINES  7000 ERASE/REVIEW IMAGES
120 REM                9000 COMPLETE GRAPH OUTLINE
130 REM               10000 DATA ENTRY
140 REM               10100 EQUATION PLOTTING
150 REM               10200 FIND LITTLE AND BIG
160 REM               10300 CALCULATE DATA FOR BORDERS
170 REM               10500 DRAW BORDERS
180 REM               10700 CONVERT USER UNITS TO GRAPH
190 REM               10800 GRAPH UNITS TO TEXT POSITION
200 REM               11000 PLOT POINTS
210 REM               11100 PLOT VECTORS
220 REM               11200 PLOT Y-BARS
230 REM               11300 PLOT X-BARS
235 REM               11500 SAVE ON DISK
240 REM               11800 SELECT COLORS
250 REM               11900 PAUSE
260 REM
270 END
490 REM WRITE EQUATION AT 500, EG: 500 Y= X^2 - 3* X
510 RETURN
6900 REM
6901 REM
6902 REM   ERASE/REVIEW IMAGES
6903 REM
7000 PLOT 2, 255, 27, 24, 6, 11, 14, 12, 3, 11, 7:REM IMAGE ERASE/REVIEW
7005 FOR I= 1TO 12:I$(I)= CHR$ (48+ I- 7* (I> 9)):NEXT I
7010 PRINT "E R A S E / R E V I E W   I M A G E S":PRINT
7020 PRINT ,,"1.  REVIEW IMAGES. ":PRINT
7030 PRINT ,,:INPUT "2.  ERASE IMAGES.  ENTER NUMBER: ";I
7040 IF I= 2THEN 7100
7050 I$= "REVIEWED":GOSUB 7200
7060 FOR I= LOWTO HIGH:PLOT 3, 64, 29, 27, 4:REM LOSE CURSOR
7070 PRINT "LOAD SCREEN. DIS;"+ I$(I):PLOT 27, 27:REM IMAGE
7080 INPUT "";I$:NEXT I:RETURN
7100 I$= "ERASED":GOSUB 7200
7110 PLOT 27, 4:FOR I= HIGHTO LOWSTEP - 1
7120 PRINT "DEL SCREEN. DIS;"+ I$(I):NEXT I
7130 PLOT 27, 27:PRINT "IGNORE FCS ERROR - EFNF";
7140 PRINT " DURING RENAMING":PLOT 17, 10, 27, 4
7150 J= HIGH- LOW+ 1:FOR I= LOWTO 12- J:REM CLOSE GAP
7160 PRINT "REN SCREEN. DIS;"+ I$(I+ J)+ "TO SCREEN. DIS;"+ I$(I)
7180 NEXT I:PLOT 27, 27:RETURN
7200 PLOT 6, 5* I- 4, 12, 27, 4:PRINT "DIR":REM DIRECTORY
7210 PLOT 27, 27:PRINT ,"IMAGES ARE LISTED  SCREEN. DIS;N  ";
7220 PRINT "WHERE N IS THE NUMBER. ":PRINT
7230 PRINT ,"ENTER #S OF FIRST AND LAST IMAGES TO BE ";I$;":"
7235 PRINT :PRINT ,,"FOR A ENTER 10, FOR B ENTER 11 ETC. "
7240 PRINT :PRINT ,,:INPUT "FIRST ";LOW:REM
7250 PRINT :PRINT ,,:INPUT " LAST ";HIGH:REM
7260 PRINT :PRINT ,,:INPUT "PUSH RETURN TO ADVANCE";I$:RETURN
```

Listing 1 continued on page 130

Major Impact.

Meet IMP 2, the stylish impact printer with three way paper handling.

Designed for desk top use, this sleek unit combines an ultra-low profile with a unique fan-cooled printing system that can knock out 80, 96, or 132 columns of crisp hardcopy with continuous throughput of one line per second.

Three way paper handling. IMP 2 features three way paper handling for forms, single sheets and paper rolls, with tractors adjustable from 1.5 inch to 9½ inches. Software control of forms length, printer select/deselect together with a choice of three standard interfaces make IMP 2 the most versatile printer available in its price range.

Interfaces abound. IMP 2 provides parallel, RS232C and 20mA current loop as standard equipment. But if you need something special, we can supply interfaces for just about any system — high speed serial, Apple, Pet, TRS-80, IEEE 488... you name it.

Versatile character sets. 96 ASCII character set is standard. And you can select six character sizes, even graphics, under software control. Options include full page buffering and special character sets.

Service — a big difference. No other printer manufacturer offers Axiom's combination of low cost plus nation-wide service and distribution — in the USA and 18 overseas countries.

Psssst — the price!!! With all this performance, the price is low. Just $795 for IMP 2 ($695 for IMP 1, without tractor feed). And that's the single unit price.

Better phone, write or mail the bingo card today!



AXIOM CORPORATION

5932 San Fernando Road, Glendale, CA 91202
Tel: (213) 245-9244 • TWX: 910-497-2283

Circle 81 on inquiry card.

Listing 1 continued:

```
8988 REM
8989 REM
8990 REM   PREPARE COMPLETE GRAPH OUTLINE
8991 REM
8992 REM               CALCULATES LIMITS, SCALE VALUES AND
8993 REM               DRAWS OUTLINE WITH TIC MARKS, SCALES,
8994 REM               TITLE AND AXES LABELS
8995 REM
9000 REM GRAPH OUTLINE
9010 GOSUB 10200:REM DATA RANGE
9020 GOSUB 10300:REM AUTOSCALE
9030 GOSUB 10500:RETURN :REM FRAME
9980 REM
9981 REM
9982 REM   ENTER:
9983 REM
9984 REM               TITLE$
9985 REM               NUMBER  OF DATA POINTS
9986 REM               LABEL$(0)  FOR X-AXIS
9987 REM               LABEL$(1)  FOR Y-AXIS
9988 REM               ARRAY(NUMBER,2)  OF DATA POINTS
9989 REM
9990 REM     NOTE: IF  CHOICE  = 1 THEN ONLY 1 AXIS IS ENTERED
9991 REM
10000 PLOT 6,1,12,14,3,18,13:REM DATA ENTRY
10010 PRINT "D A T A   E N T R Y"
10015 PLOT 10,9,9:INPUT "GRAPH TITLE: ";TITLE$
10020 PLOT 10,9,9:INPUT "NUMBER OF DATA POINTS: ";NUMBER
10021 DIM ARRAY(NUMBER+ 2,2)
10024 PLOT 10,9,9:INPUT "X-AXIS UNITS, INDEPENDANT: ";LABEL$(0)
10025 IF CHOICE= 1THEN LABEL$(1)= "NUMBER":GOTO 10030
10026 PLOT 10,9,9:INPUT "Y-AXIS UNITS,    DEPENDANT: ";LABEL$(1)
10028 LABEL$(2)= LABEL$(1)
10030 FOR ITEM= 1TO NUMBER:REM ENTER POINTS
10040 IF ITEM- 1< > 10* INT ((ITEM- 1)/ 10)THEN 10060:REM PAGE
10050 PLOT 12,10,10:PRINT "POINT",,LABEL$(0):REM
10055 IF CHOICE< > 1THEN PLOT 28:PRINT ,,,,"";LABEL$(1)
10060 IF ITEM- 1= 5* INT ((ITEM- 1)/ 5)THEN PLOT 10:REM SPACE
10070 PRINT :PRINT "";ITEM,,:INPUT "";ARRAY(ITEM,0):REM
10075 IF CHOICE= 1THEN NEXT ITEM:RETURN
10080 PLOT 28,18,9,9,9,9:INPUT "";ARRAY(ITEM,1)
10085 ARRAY(ITEM,2)= ARRAY(ITEM,1):NEXT ITEM:RETURN
10090 REM
10091 REM
10092 REM   WRITE EQUATION
10093 REM
10094 REM               TESTS IS THE EQUATION WRITTEN
10095 REM               INPUT  LITTLE(0)
10096 REM               INPUT  BIG(0)
10097 REM               CALCULATES  ARRAY(25,2)  FROM EQUATION
10098 REM
10100 PLOT 6,5,14,12,3,12,7:REM EQUATION PLOTTING
10110 PRINT "E Q U A T I O N   P L O T T I N G":PRINT :REM
10120 NUMBER= 25:X= 1:Y= .9999:GOSUB 490
10130 IF Y< > .9999THEN 10140:REM JUMP IF EQUATION AT LINE 500
10132 PLOT 3,16,11:PRINT "TYPE EQUATION AT LINE 500":PRINT
10133 PRINT ,,"USING THE RULES OF BASIC ":PRINT :PRINT
10134 PRINT ,,"EXAMPLE:  500 Y=X^2-3*X":PRINT :REM
10135 PRINT ,,"NOW TYPE  500 ...... ":PRINT
10136 PRINT ,,"THEN TYPE  RUN  AND PRESS  RETURN":END
```

Listing 1 continued on page 132



EVERYONE WINS

Selecting software for your Ohio Scientific computer is a chancy task at best. There are few trustworthy vendors with a national reputation. There are no consistent quality standards and the documentation is often cryptic and inaccurate. If you are lucky enough to find a good package, there's no guarantee of ongoing support. A wrong choice results in months of wasted time, effort, and money.

With the Software Federation, you no longer take that risk. The Software Federation was formed by three of the largest Ohio Scientific hardware distributors to select and market quality software through reputable dealers nationwide.

DEALERS

The Software Federation solves the dealer's problems by providing low cost access to high quality software with the sort of demonstration packages, documentation, and support that the dealer needs to successfully sell machines.

AUTHORS

The Software Federation solves the independent vendor's problems by providing a proprietary method of software protection, aggressive enforcement of software licenses, a strong dealer base, primary support, and national advertising.

END USERS

The Software Federation solves the user's problems by providing quality software, exceptional documentation, after-the-sale support, and optional software maintenance services.

Why risk making the wrong choice? With the Software Federation, everyone wins!

See the dealer in your area for a complete turnkey demonstration.

Software Packages

BUS-I Original of popular series, sold "as is" **$99**
BUS-II Unlicensed version of BUS-I **$150**
BUS/DMS Most current version of BUS series, completely reworked, DMS compatible **$850**
fig-FORTH A complete Forth Interest Group version for OSI. Not a kludge **$175**
MEMTEST/2 New edition of popular memory test **$50**
WP-INT Interface between WP-2 and OSI-DMS for form letters **$80**
Amway Distributors Package **$995**
DATA DIRECTOR Complete rewrite of OSI-DMS Nucleus by BBS, command oriented, very interactive **$995**
System Exerciser Self-prompting test routines for end user troubleshooting **$60**
Med-Bill/Faragher Single doctor client billing **$995**
Manufacturing Control System Hard disk based. Standalone inventory with job costing and bill-of-materials **$3500**
Fast Floppy Dumper Floppy disk backup for hard disk systems **$125**
WP6502 65U word processor from DQFLS **$125**
USUS Software Exchange Library 6 disk set of UCSD Pascal programs, includes USUS membership **$80**
Mailer Text processor, keyed files & sort capability, good mass mailer, DMS compatible **$190**
Payroll Very thorough package for floppy or hard disk, DMS compatible **$495**
General Ledger Multi-division/department support, journal based, floppy or hard disk, DMS compatible **$495**

Affiliated Dealers

TriComp Inc. Denver, CO 80221
Total Data Systems Ft. Collins, CO 80525
Data Services Computer Corp. Denver, CO 80239
Tra-Sta Computer Shoppe Pueblo, CO 81005
Business Data Systems, Inc. Boulder, CO 80301
Tek-Aids Industries Inc. Arlington Hts., IL 60004
KMH Galesburg, IL 61401
Practical Computer Springfield, IL 62703
Databus Grayslake, IL 60038
MAP Systems Peoria Hts., IL 61614
Business Computer of Joliet Cresthill, IL 60435
Cybertronics Houston, TX 77084
CSB Houston, TX 77057
Computer Management Systems Mitchell, SD 57301
Frisch Computer St. Paul, MN 55113
Farragher & Assoc. Milwaukee, WI 53213
Specialized Computer Systems Jackson, MI 49204
Community Computers Arlington, VA 22201
Delta Data Distributors Memphis, TN 38118
International Automation New Kensington, PA 15608
Whitlock International, Inc. Detroit, MI 48219

Software Federation INC
44 University Drive
Arlington Hts., IL 60004
Phone: 312/259-1355



Listing 1 continued:

```
10140 IF TITLE$< > ""THEN 10145
10142 PRINT :PRINT ,,"ENTER TITLE (E.G: EQUATION): "
10143 PRINT :PRINT ,,:INPUT "";TITLE$
10145 PRINT :PRINT ,,:INPUT "ENTER LOWEST X VALUE: ";LITTLE(0)
10150 PRINT :PRINT ,,:INPUT "     HIGHEST X VALUE: ";BIG(0)
10160 X= LITTLE(0):FOR ITEM= 1TO 25:GOSUB 490:REM Y FROM EQUAN
10170 ARRAY(ITEM,0)= X:ARRAY(ITEM,1)= Y
10180 X= X+ (BIG(0)- LITTLE(0))/ 24:NEXT ITEM:RETURN :REM INC X
10190 REM
10191 REM
10192 REM   FIND LITTLE(AXIS) AND BIG(AXIS)
10193 REM              FROM  ARRAY(NUMBER,1) IN BOTH AXES
10194 REM
10200 FOR AXIS= 0TO 1:GOSUB 10210:NEXT AXIS:RETURN :REM LO, HI
10210 LITTLE(AXIS)= ARRAY(1,AXIS):BIG(AXIS)= ARRAY(1,AXIS)
10215 FOR ITEM= 1TO NUMBER
10220 IF ARRAY(ITEM,AXIS)> LITTLE(AXIS)THEN 10230
10225 LITTLE(AXIS)= ARRAY(ITEM,AXIS)
10230 IF ARRAY(ITEM,AXIS)< BIG(AXIS)THEN 10240
10235 BIG(AXIS)= ARRAY(ITEM,AXIS)
10240 NEXT ITEM:RETURN
10288 REM
10289 REM
10290 REM   CALCULATE FRAME FROM LITTLE(AXIS) AND BIG(AXIS)
10291 REM
10292 REM              JUMP(AXIS)   IS STEP LENGTH
10293 REM              LOW(AXIS)    IS SCALE LOW
10294 REM              HIGH(AXIS)   IS SCALE HIGH
10295 REM              SCALE(AXIS)  IS SCALE LENGTH
10296 REM              GAPS(AXIS)   IS NUMBER OF STEPS
10297 REM
10300 FOR AXIS= 0TO 1:GOSUB 10310:NEXT AXIS:RETURN :REM SCALE
10310 RANGE= (BIG(AXIS)- LITTLE(AXIS))/ 1.21
10315 JUMP(AXIS)= 4* 10^ (INT (.434295* LOG (RANGE)))
10320 DEF FN I(I)= JUMP(AXIS)* INT (I/ JUMP(AXIS)+ .0001)
10325 FOR I= 1TO 3:JUMP(AXIS)= JUMP(AXIS)/ 2
10330 HIGH(AXIS)= - FN I(- BIG(AXIS))
10340 LOW(AXIS)= FN I(LITTLE(AXIS))
10350 SCALE(AXIS)= HIGH(AXIS)- LOW(AXIS)
10360 GAPS(AXIS)= INT (1.0001* SCALE(AXIS)/ JUMP(AXIS))
10370 IF GAPS(AXIS)< 4THEN NEXT I
10380 EVEN= 2* JUMP(AXIS)* INT (- SCALE(AXIS)/ JUMP(AXIS)/ 2.1)
10390 HIGH(AXIS)= LOW(AXIS)- EVEN
10395 SCALE(AXIS)= HIGH(AXIS)- LOW(AXIS):RETURN
10480 REM
10481 REM
10482 REM   DRAW BORDERS WITH SCALES AND TITLES
10483 REM
10484 REM              USER MAY ALTER
10485 REM              MINSCREEN(AXIS)  AND  MAXSCREEN(AXIS) BUT
10486 REM              SELECT VALUES TO MAKE
10487 REM              RANGE  A MULTIPLE OF 24.  ALSO:
10489 REM
10490 REM              IN 0 AXIS VALUES MUST BE MULTIPLES OF 2
10491 REM              IN 1 AXIS VALUES MUST BE MULTIPLES OF 4
10492 REM
10493 REM              RATIO(AXIS)  IS CALCULATED FROM
10494 REM              RANGE  AND  SCALE(AXIS)
10495 REM
```

Listing 1 continued on page 134

Listing 1 continued:

```
10496 REM                PLACE  IS CALCULATED FOR
10497 REM                TIC MARKS AND SCALE NUMBERS
10498 REM
10500 PLOT 2,255,27,24,29,15,6,COLOUR(1),12:REM DRAW FRAME
10505 MINSCREEN(0)= 18:MAXSCREEN(0)= 114
10510 MINSCREEN(1)= 16:MAXSCREEN(1)= 112
10515 FOR AXIS= 0TO 1:RANGE= MAXSCREEN(AXIS)- MINSCREEN(AXIS)
10520 RATIO(AXIS)= RANGE/ SCALE(AXIS):NEXT AXIS
10522 PLOT 3,(MAXSCREEN(0)+ MINSCREEN(0))/ 4- LEN (TITLE$)/ 2
10523 PLOT 29- MAXSCREEN(1)/ 4:PRINT TITLE$
10525 FOR AXIS= 0TO 1
10530 PLOT 6,COLOUR(1),2,250- 4* AXIS,MINSCREEN(AXIS)- 1
10540 PLOT MINSCREEN(1- AXIS)- 1
10545 PLOT MAXSCREEN(AXIS)+ 2- 2* (AXIS= 1)
10550 PLOT MAXSCREEN(1- AXIS)+ 2- 2* (AXIS= 0)
10555 PLOT MAXSCREEN(AXIS)+ 2- 2* (AXIS= 1),255
10560 J= JUMP(AXIS)/ 2
10565 FOR PLACE= LOW(AXIS)TO HIGH(AXIS)+ JSTEP JUMP(AXIS)
10570 GOSUB 10700:REM TIC MARKS
10580 GRAPH(1- AXIS)= MINSCREEN(1- AXIS)- 2:REM OUTSIDE FRAME
10590 PLOT 6,COLOUR(1):GOSUB 11010
10600 PLOT 6,COLOUR(2):REM NUMBERS
10620 IF ABS (PLACE)< JUMP(AXIS)/ 2THEN PLACE= 0:REM NO EXPON
10630 GRAPH(1- AXIS)= MINSCREEN(1- AXIS)- 8+ 4* AXIS
10640 GOSUB 10800:PLACE$= STR$ (PLACE)
10650 PLOT 3,TEXT(0)- LEN (PLACE$)/ (2- AXIS),TEXT(1)
10660 PRINT PLACE$:NEXT PLACE:NEXT AXIS
10662 PLOT 3,MAXSCREEN(0)/ 2- 4- LEN (LABEL$(0))
10664 PLOT 34- MINSCREEN(1)/ 4:PRINT LABEL$(0)
10666 PLOT 3,MINSCREEN(0)/ 2- 6,29- MAXSCREEN(1)/ 4
10670 PRINT LABEL$(1):RETURN
10688 REM
10689 REM
10690 REM   CALCULATE SCREEN GRAPH POSITION
10691 REM
10692 REM                CONVERTS  PLACE  IN USER UNITS
10693 REM                TO  GRAPH(AXIS)  FROM
10694 REM                RATIO(AXIS), LOW(AXIS), MINSCREEN(AXIS)
10695 REM
10700 J= RATIO(AXIS)* (PLACE- LOW(AXIS)):REM CONVERT USER UNITS
10710 GRAPH(AXIS)= MINSCREEN(AXIS)+ J+ .0001:RETURN
10790 REM
10791 REM
10792 REM   CALCULATE SCREEN TEXT POSITION
10793 REM
10794 REM                CONVERTS  GRAPH(AXIS)  PLOTTING UNITS
10795 REM                TO  TEXT(AXIS)  FOR CURSOR POSITION
10796 REM
10800 TEXT(0)= GRAPH(0)/ 2:REM GRAPH UNITS TO CURSOR POS
10810 TEXT(1)= INT (31.75- GRAPH(1)/ 4):RETURN
10988 REM
10989 REM
10990 REM   PLOT POINTS OR LINES
10991 REM
10992 REM                ARRAY(NUMBER,1)  IS PLOTTED EITHER
10993 REM                AS POINTS OR AS CONTINUOUS LINE
10994 REM
11000 FLAG= 1:GOSUB 11150:RETURN :REM POINTS
11010 PLOT 2,GRAPH(0),GRAPH(1),255:RETURN :REM POINT
```

Listing 1 continued on page 138

The Perfect Fit

The Micromodem II data communications system and the Apple II* computer. What better combination to maximize the capabilities of your personal computer!

This popular direct connect modem can transmit data between an Apple II and another Apple II, a terminal, another microcomputer, minicomputer or even a large time-sharing computer anywhere in North America. The Micromodem II has unique automatic dialing and answer capabilities which further increases the communications possibilities between the Apple II and another computer or terminal.

You can send and/or receive messages or data when you are out of your office, home or out of town. Your branch business locations can communicate with each other regarding inventory and other matters over the phone. Or you can communicate with friends across the country. And you can access information utilities like the SOURCE for various business and personal applications.

The Micromodem II consists of two parts. One part includes the printed circuit board which holds the Micromodem II, ROM firmware and the serial interface. The board plugs directly into the Apple II providing all the functions of a serial interface card plus programmable auto dialing and auto answer capabilities. The on-board ROM firmware enables the Micromodem II to operate in any of three modes to perform different tasks-terminal mode, remote console and program control mode.

The other part of the Micromodem II datacomm system is a Microcoupler which connects the Micromodem board and Apple II to a telephone line. The Microcoupler gets a dial tone, dials numbers, answers the phone and hangs up when a transmission is over. There are none of the losses or distortions associated with acoustic couplers. The Microcoupler is compatible with any North American standard telephone lines and is FCC-approved for direct connection in the U.S. It works with standard dial phone service or Touch-tone service.

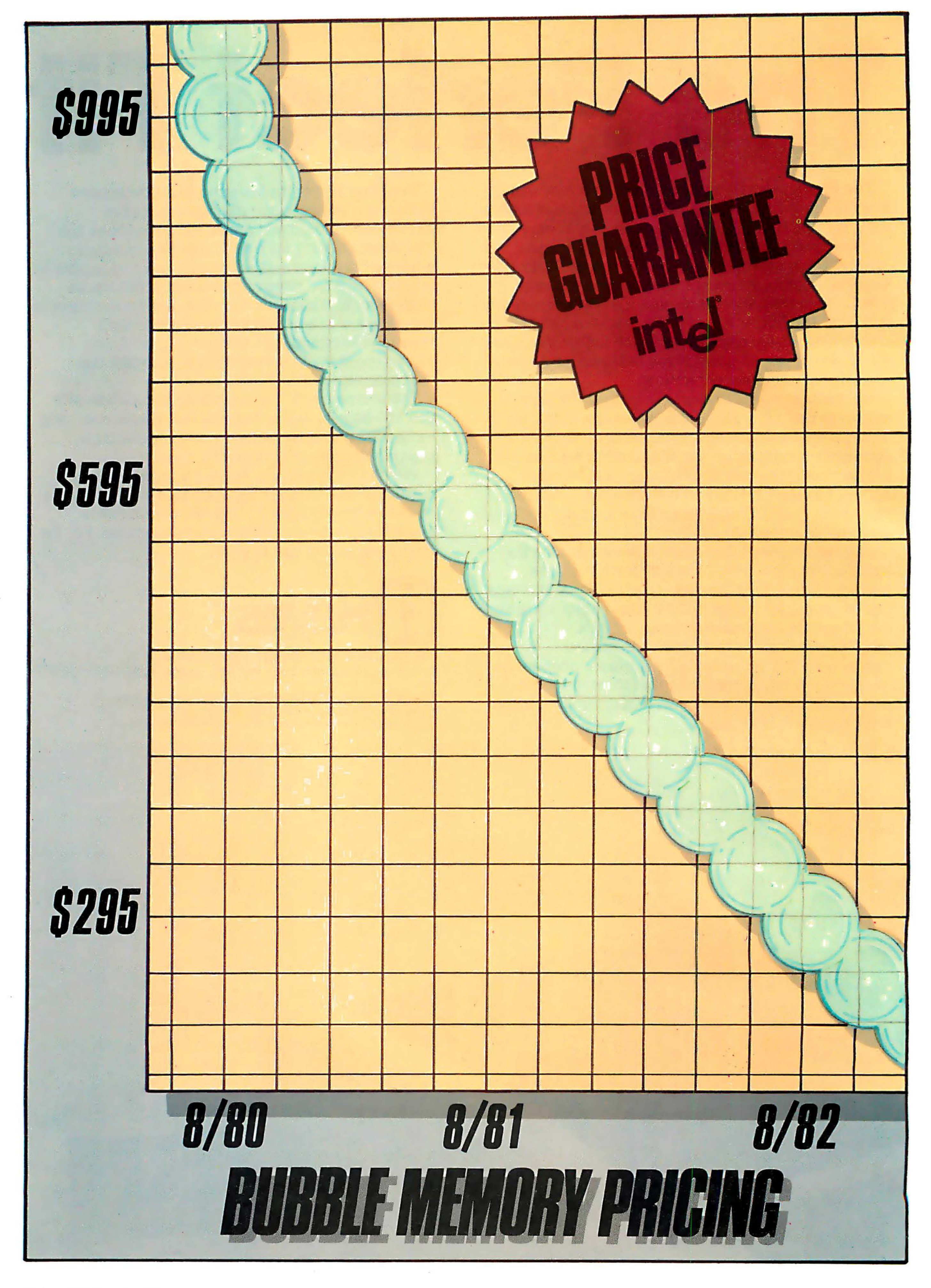
The Micromodem II is completely compatible with Bell 103-type modems. Full and half-duplex operating modes are available as well as speed selectable transmission rates of 110 and 300 bps.

Why not increase your Apple II's capabilities by outfitting it with the sophisticated Micromodem II data communications system? The Micromodem II is available at retail computer stores nationwide. For the store nearest you, call or write:



Hayes Microcomputer Products Inc.
5835 Peachtree Corners East, Norcross, Georgia 30092 (404) 449-8791

™ Micromodem II is a trademark of Hayes Microcomputer Products, Inc.
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The Micromodem II can also be used with the Bell & Howell computer.


$995
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PRICE GUARANTEE
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BUBBLE MEMORY PRICING

Bubble Price Break

Intel reduces prototyping prices of 1-megabit bubble memories by 40% now. And guarantees a volume price of $595 for complete component sets by August 1981.

Fast-breaking bubble technology. You've been hearing about it for years. Now Intel announces the kind of break you've been waiting for: a price break.

On August 11th, Intel lowered its 100-unit price for the BPK72 Bubble Memory Kit by 40% to $995—less than 100 millicents per bit.

By August 1981, the price of megabit bubble memories ordered in 5,000-unit lots will be an unprecedented $595. That's 60 millicents per bit. Not "projected." Not "expected." *Guaranteed.*

One year later, for 25,000-piece orders, the unit price will be $295—cutting the per-bit price in half once more. Again, we guarantee it.

How can Intel guarantee such a sharp price reduction? Simple. Intel was the first to bring production 1-megabit bubble memories to market. We've been delivering them for over a year, for a wide range of applications, and now we're moving prices down the manufacturing learning curve.

Get more than bubbles

Intel's bubble memory is a complete set of bubble components for microprocessor-based applications. This set consists of six special support ICs: a controller, a formatter/sense amp., three packages for coil driving and a current pulse generator. It interfaces to Intel® and other microprocessor system buses via the controller, which handles up to eight bubble memory packages, and provides built-in power fail protection and error correction.

The bubble element and its small set of associated ICs can be treated as a peripheral subsystem. This allows designers to concentrate on higher level system objectives, instead of spending time learning the intimate details of bubble device interfacing. Thus minimizing expense in hardware and software development.

Add more value to your product

With Intel's solid-state bubble memory, all that moves is the information. That means high reliability and low maintenance for your products, even in harsh or unclean environments—the kind where disks and tapes won't go. And since the memory is completely nonvolatile, your data remains secure when the power goes off. No battery backup or replacement is necessary.



Furthermore, Intel's bubble memory system is small, lightweight and silent. By packing over 1 million bits into less than 100 square centimeters of board space, it allows you to reduce the size, weight and power consumption of your products.

As the natural mass storage for LSI microprocessor-based systems, Intel's megabit bubble memory makes it practical to design more features into your equipment. So now you can build in programmability. Portability. Reduced service and repair costs. All with ensured data integrity, even in hostile environments. Consider what that means in your applications.

Start designing now

Everything you need to start designing your next generation product is included in our Bubble Memory Prototype Kit (BPK72), available now from distributor stock. It contains all the components necessary for a 1-megabit system, plus a printed circuit board and complete documentation.

To find out how bubble memories can give you that competitive edge in your next project—and to receive our bubble brochure, contact your local Intel sales office/distributor. Better yet, have one of our field sales engineers give you a firm quote based on exactly what you need for your next product. Write Intel Corporation, 3065 Bowers Avenue, Santa Clara, CA 95051. Or call (408) 987-8080.

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Circle 85 on inquiry card.

Listing 1 continued:

```
11020 PLOT 2,242,GRAPH(0),GRAPH(1),255:RETURN :REM VECTOR
11100 FLAG= 0:GOSUB 11150:RETURN :REM VECTORS
11150 PLOT 6,COLOUR(3):FOR ITEM= 1TO NUMBER:FOR AXIS= 0TO 1
11160 PLACE= ARRAY(ITEM,AXIS):GOSUB 10700:NEXT AXIS
11170 ON 2+ (ITEM= 1OR FLAG= 1)GOSUB 11010,11020
11180 NEXT ITEM:RETURN
11188 REM
11189 REM
11190 REM   PLOT BAR GRAPHS
11191 REM
11192 REM             ARRAY(NUMBER,1)  IS PLOTTED EITHER
11193 REM             AS VERTICAL OR AS HORIZONTAL BARS
11194 REM
11200 FLAG= 1:GOSUB 11310:RETURN :REM Y-BAR
11300 FLAG= 0:GOSUB 11310:RETURN :REM X-BAR
11310 COLOUR= 2:FOR ITEM= 1TO NUMBER
11320 COLOUR= COLOUR+ 1+ 2* (COLOUR= 4):PLOT 6,COLOUR(COLOUR)
11330 FOR AXIS= 0TO 1:PLACE= ARRAY(ITEM,AXIS)
11340 GOSUB 10700:NEXT AXIS
11350 PLOT 2,250- FLAG* 4,MINSCREEN(FLAG):REM X OR Y BAR
11360 FOR I= GRAPH(1- FLAG)TO GRAPH(1- FLAG)+ 1
11370 PLOT I,GRAPH(FLAG):NEXT I:PLOT 255:NEXT ITEM:RETURN
11490 REM
11491 REM
11492 REM   SAVE IMAGES ON DISK
11493 REM
11494 REM             IMAGES SAVED AS  SCREEN.DIS
11495 REM
```

Listing 1 continued on page 140

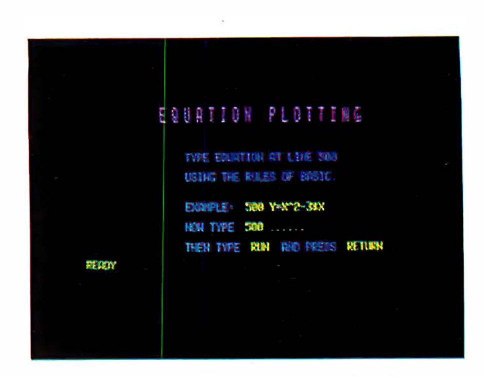


Photo 1: *Variation of text height and color. Both text height and color can be changed under program control.*

Text continued from page 126:

Subscripts for array variables commence at 0. In consequence, if NUMBER = 25 and AXES = 1, then the BASIC statement DIM ARRAY (NUMBER, AXES) will define an array with dimensions 26 and 2.

Values of 0 or −1 are assigned to results of logical operations: 0 for false and −1 for true. This poperty is used in line 11170 of listing 1.

It is also possible to change the height and color of displayed text (as shown in photo 1); this is done occasionally within the body of the program in listing 1.

The Subroutines

Listing 1 contains the subroutines that together can be used to produce a graph on the color video-display screen. Subscripted variables, when used with a subscript of 0, refer to some horizontal component of the graph; a subscript of 1 refers to some vertical component of the graph. Certain calculation subroutines (for example, 10200 and 10300) can be accessed at a line ending in "00" to perform calculations for both the X and Y axes, or they can be accessed at the corresponding line ending in "10" to calculate for only one axis.

Some of the more important subroutines are described briefly in the paragraphs that follow:

- 7000—Review or erase images; this subroutine enables graphs stored on disk to be reviewed (displayed) or erased from the disk.
- 9000—Prepare complete graph outline; this subroutine consists of three subroutines that examine the data and draw the appropriate graph frame (see also subroutines 10200, 10300, and 10500).
- 10000—Data entry; the title of the graph, the axes' labels, and data



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Listing 1 continued:

```
11500 PLOT 6,COLOUR(2),3,0,31,11,3,13,31:REM SAVE ON DISK
11510 INPUT "ENTER S TO SAVE, OR PRESS RETURN: ";I$:PLOT 28,11
11520 IF I$< > "S"THEN 11540
11530 PLOT 27,4:PRINT "SAVE SCREEN.DIS 6300-6FFF":PLOT 27,27
11540 RETURN
11780 REM
11781 REM
11782 REM   SELECT COLORS
11783 REM
11784 REM                 COLOUR(1)   FRAME
11785 REM                 COLOUR(2)   SCALE
11786 REM                 COLOUR(3)   GRAPH 1
11787 REM                 COLOUR(4)   GRAPH 2
11788 REM
11800 PLOT 6,4,3,0,31,11,3,16,31:REM COLOR SELECTION
11802 INPUT "ENTER C TO CHANGE COLOR: ";K$
11804 PLOT 6,COLOUR(2),3,0,31,11:IF K$< > "C"THEN RETURN
11806 PLOT 6,38,12,3,23,7,14:PRINT "COLOR SELECTION"
11810 PRINT :PRINT ,,:INPUT "TOUCH COLOR FOR BACKGROUND: ";I$
11820 I= (ASC (I$)- 16)* 8:PLOT 6,I,12,3,16,11:REM BKD
11830 PLOT 6,I/ 8* 9+ 2+ 4* (I> 40)
11840 DATA "FRAME","SCALES","GRAPH1","GRAPH2":RESTORE 11840
11850 FOR J= 1TO 4:READ I$:PLOT 3,16,9+ 2* J:PRINT "FOR ";I$;
11860 INPUT "";J$:COLOUR(J)= I+ ASC (J$)- 16
11870 PLOT 6,COLOUR(J),3,32,9+ 2* J:PRINT I$:NEXT J:RETURN
11890 REM
11891 REM
11892 REM   PAUSE
11893 REM
11894 REM                 "PRESS RETURN TO CONTINUE"
11895 REM                 BLINKS BRIEFLY AT BOTTOM OF GRAPH
11896 REM
11900 PLOT 6,COLOUR(1),31,3,18,31:REM PAUSE
11910 PRINT "PRESS RETURN TO CONTINUE":FOR I= 1TO 1000:NEXT I
11920 PLOT 15,3,0,31,11:INPUT "";I$:RETURN
```

PLOT 2	Enter graph-plotting mode
PLOT 2, X, Y	Point at X,Y
PLOT 2, 242, X, Y	Vector to X,Y
PLOT 2, 250, X0, Y, XM	Horizontal bar at Y from X0 to XM
PLOT 2, 246, Y0, X, YM	Vertical bar at X from Y0 to YM
PLOT 3, T, L	Cursor to tab T at line L
PLOT 6, C	Defines the color of both the foreground and background
PLOT 8	Cursor to home
PLOT 9	Tab 8 spaces
PLOT 10	Line feed (move cursor down one line)
PLOT 11	Erase line
PLOT 12	Erase page
PLOT 14	Double-height text
PLOT 15	Normal-height text, with blink mode off
PLOT 16 thru PLOT 23	Changes color of foreground or background (whichever is active)
PLOT 27, 4: PRINT "[disk commands]":	
PLOT 27, 27	Execute floppy-disk command
PLOT 27, 10	Write text vertically
PLOT 27, 24	Write text horizontally
PLOT 28	Cursor up
PLOT 29	Enable background color
PLOT 31	Blink on
PLOT 255	Cancel graph-plotting mode

Table 2: *Table of plot codes in Compucolor BASIC. Many functions associated with the color video-display screen are achieved by the use of the PLOT command. The table of PLOT commands here includes all those used in listings 1 and 2.*

Range of Values, R, to Be Plotted	Initial Value for JUMP
0.121 ≤ R < 1.21	0.4
1.21 ≤ R < 12.1	4.0
12.1 ≤ R < 121	40.0
121 ≤ R < 1210	400.0
1210 ≤ R < 12100	4000.0

Table 1: *Initial value for step size (JUMP) given the range (R) of the variable to be plotted. The table can be continued in both directions by either multiplying or dividing all the numbers in a line by 10. Once the initial value for JUMP is found, it is repeatedly divided by 2 until the step size used subdivides the range into at least four intervals—that is, until JUMP ≤ (R/4).*

are entered in this subroutine. Certain applications (eg: histograms) require only one set of data to be entered. If CHOICE=1, then the subroutine fills only ARRAY (*n*,1), that is, the data entries are placed in ARRAY (0,0), ARRAY (1,0), ARRAY (2,0), and so on. If CHOICE is not equal to 1, then this subroutine expects two sets of data to be entered, filling both ARRAY (*n*,0) and ARRAY (*n*,1). The Y-axis data is duplicated in a third column, ARRAY (*n*,2), thus allowing this data to be manipulated later without being destroyed.

- 10100—Equation plotting; this subroutine tests to see that no equation exists, then invites the user to write an equation at line 500. The equation takes the form Y= (some arithmetic expression using X). Once the equation exists, the subroutine asks for a title and the X-axis limits. The program then uses the equation to calculate twenty-five equidistant data points to fill ARRAY (*n*,1).
- 10200—Find big and little; this subroutine determines the largest and smallest values for the data and stores them in arrays BIG (*n*) and LITTLE (*n*).
- 10300—Prepare values for frame; the step size (JUMP) is calculated in accordance with the constraints described above. This value is used to determine the HIGH and LOW values for the scale. GAPS is the number of JUMPS in the length of the axis (variable SCALE).
- 10500—Draw borders with scales and titles; this subroutine draws

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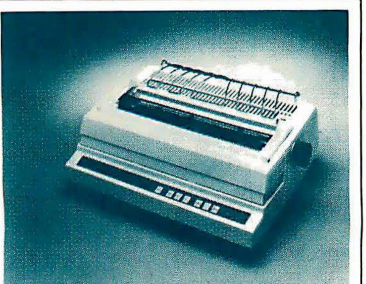


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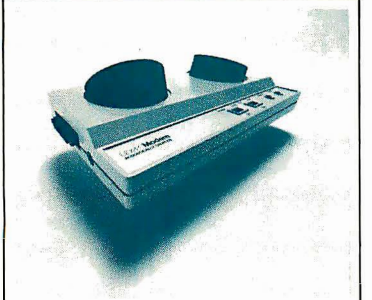
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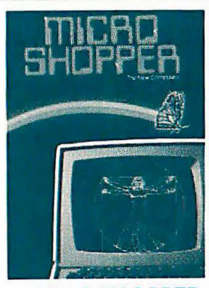
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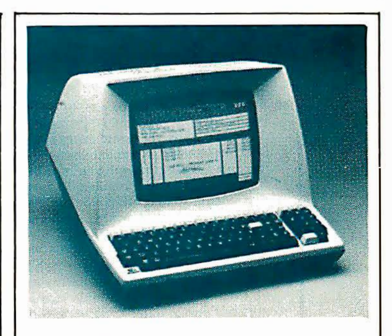
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Listing 2: *Demonstration program for the subroutines of listing 1. This short program, when added to the program in listing 1, allows the user to make a graph of a collection of points, an equation, or a series of vertical bars.*

```
5 REM KY 5 REM      GRAPHS. (C)  A. W. GROGONO.   AUG.  1979
6 REM      DEMONSTATION PROGRAM FOR USE WITH SUBROUTINES
40 RESTORE :CLEAR 200:DIM I$(12)
50 DATA 1,2,6,4:FOR I= 1TO 4:READ COLOUR(I):NEXT I
90 PLOT 29,27,24,15,14,2,255,6,1,12,3,16,3:REM CLEAR PAGE
280 REM
290 REM
300 PRINT "S E L E C T   G R A P H   T Y P E:":PRINT
310 PRINT :PRINT ,,"1.  X/Y SCATTER"
320 PRINT :PRINT ,,"2.  PLOT EQUATION"
330 PRINT :PRINT ,,"3.  Y-BAR GRAPH"
340 PRINT :PRINT ,,,:INPUT "ENTER 1 - 3: ";K:PLOT 28,11
350 IF K< 1OR K> 3THEN 340
360 IF K< > 2THEN 390
370 RESTORE :CLEAR 200:FOR I= 1TO 4:READ COLOUR(I):NEXT I
380 K= 2:DIM ARRAY(25,1):REM DIMENSIONS FOR EQUATION
390 ON KGOSUB 10000,10100,10000:REM PREPARE DATA ARRAY
400 GOSUB 9000:REM FRAME
410 ON KGOSUB 11000,11100,11200:REM SCATTER, LINE, Y-BARS
420 GOSUB 11900:REM PAUSE
430 GOSUB 11500:REM SAVE
440 GOSUB 11800:REM SELECT COLORS
450 IF K$= "C"THEN 400
460 GOTO 5
```


the borders for the graph with its scales, labels, and title. The length of each number or word is employed to ensure appropriate positioning. The value of RATIO, calculated here, is used in the subroutine at line 10700.

- 10700—Convert units to screen; a value on one of the axes (in variable PLACE) is converted to its corresponding screen position (stored in variable GRAPH).
- 10800-Converts units for text position; a screen position variable, GRAPH, is converted to its corresponding cursor position and stored in variable TEXT.
- 11000 and 11100—Plot points or lines; the data points in ARRAY are plotted as separate points (11000) or as points joined by lines (11100).
- 11200 and 11300—Plot Y-bars or X-bars; the quantities in ARRAY are plotted as vertical (11200) or as horizontal bars (11300).
- 11500—Save image on disk; this subroutine transfers the finished graph to disk for recall later.
- 11800—Select colors; the colors for the background, frame, scales, and graphs are selected with this routine.
- 11900—Pause; this subroutine causes the words "PRESS RETURN TO CONTINUE" to flash briefly beneath the graph.

A Demonstration Program

The program in listing 2 was written to demonstrate the color-graphics subroutines. Graph type 1 allows data to be entered and displayed as separate points. The program initially selects the colors shown in photo 2a, but the user can select his own colors, as shown in photo 2b.

Photos 3a and 3b illustrate the use of the equation-plotting subroutine, graph type 2. Photo 3a shows the program colors for the first range selected (−2 to +2); photo 3b shows a different set of colors selected by the user for the longer range (−4 to +4). Photo 4a shows how a variable, such as income, can be displayed as a Y-bar, as an example of graph type 3. Photos 4b and 4c show the same data using different colors selected by the user.

The brevity of listing 2 shows that minimal program writing is required to produce these graphs. In fact, if only one type of graph is required

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(eg: points joined by lines), then the total program would be:

```
300 GOSUB 10000 : REM DATA
        ENTRY
310 GOSUB  9000 : REM FRAME
320 GOSUB 11100 : REM PLOT
        LINES
330 GOSUB 11900 : REM PAUSE
340 END
```

Of course, this assumes the presence of the subroutines given in listing 1.

In such a program and in the demonstration program, the X-axis and Y-axis graph scales are determined automatically by the program except where the user selects the X-axis limits for the equation.

Summary

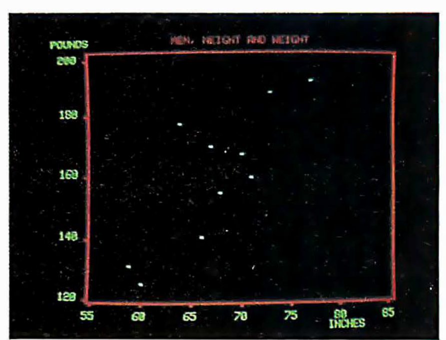
The subroutines in listing 1 were written to illustrate the principles used in determining neat graph scales, and emphasis has been placed on these calculations. The frame is drawn just outside the area in which points will be graphed. This avoids the problem of graphing points that lie directly on the frame; it also avoids the possibility of the color for a nearby graph point spilling onto the frame. The program generates an even number of scale increments for each axis; this ensures uniform spacing of both tick marks and numbers. Colors are critical when the screen is being photographed; light colors on dark backgrounds show up best (this is discussed in detail in my previous article in the January 1980 BYTE).

These subroutines can be used in many graphics applications. As written, they employ two-letter names as well as the variables X, Y, I, J, K, I$, J$, and K$. This allows the user all the remaining single letters. If the user's program defines NUMBER (number of points) and fills ARRAY with the appropriate data, then the subroutines in listing 1 can be used to generate a graph. The graph will be labeled as well if the user defines the variables TITLE$, LABEL$(0), and LABEL$(1).

The photographs used to illustrate this article have been created using a Compucolor II with 16 K bytes of user memory but without the Pincushion Correction Kit. The barrel distortion on the top and bottom can be reduced by using a telephoto lens, but the pincushion effect on each side will then be worse unless the correction kit is installed.

Next month, Part 2 of this article will use the subroutines given here to construct several other kinds of graphs: a different kind of equation-plotting routine, a histogram with the equivalent Gaussian (bell-shaped) curve superimposed, linear and other kinds of regression plotting, and a monthly analysis graph of more than one variable. ■

2a



2b

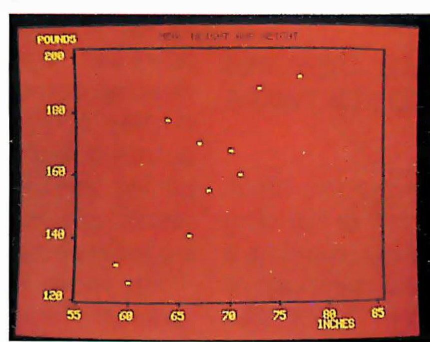
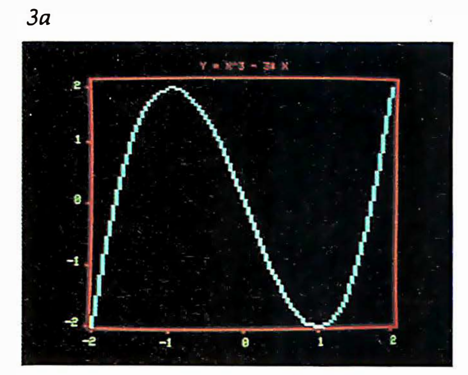


Photo 2: *Examples of point-plotting mode. The computer automatically chooses the colors of photo 2a, but the user can override this to select any other color combination, as in photo 2b. The slight "pincushion" effect can be eliminated by the addition of a corrective kit supplied by Compucolor.*

3a



3b

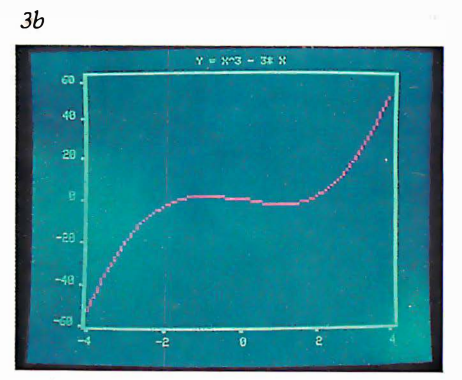
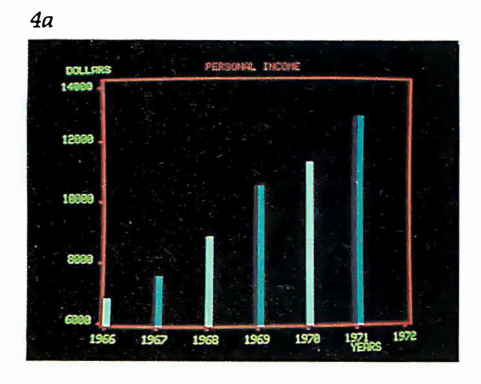
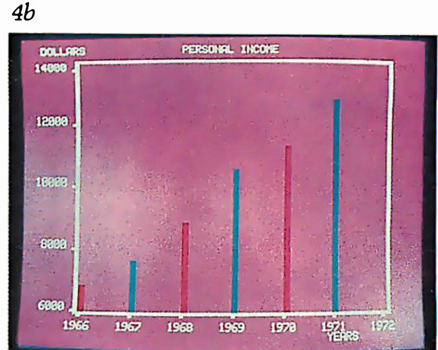


Photo 3: *Examples of equation-plotting mode. The range of both the X and Y axes can be changed, as can the choice of colors. Photo 3a illustrates the standard colors as selected by the computer; photo 3b shows another graph with colors of the user's choice.*

4a



4b



4c

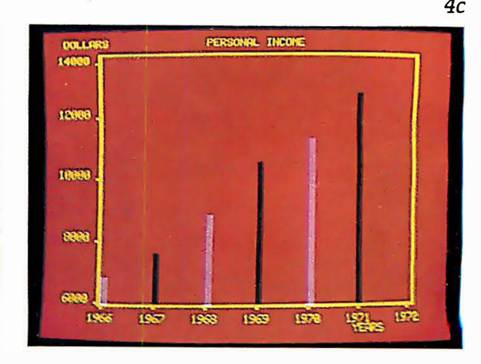


Photo 4: *Examples of bar-graph-plotting mode. Here, the same data is displayed in the standard colors (photo 4a) and two sets of user-selected colors (photos 4b and 4c). Horizontal bar graphs can also be displayed.*

Programming Quickies

Simple Base Conversions for the TRS-80

James M Curran, 24 Greendale Rd, Cedar Grove NJ 07009

I have noticed that decimal-to-hexadecimal and decimal-to-octal conversions are usually accomplished by means of subroutines, most of which require three to four statements. This is efficient enough for users of a low-level BASIC; however, computer enthusiasts with a BASIC interpreter containing the DEF FN (define function) command long for a simple one-statement conversion. Here are such conversion statements. For those of you who need to convert hexadecimal or octal to decimal, these conversions are also included. I have even thrown in a decimal-to-binary function.

Listing 1: *Definitions for five base-conversion functions. The first statement defines the function for converting decimal to binary numbers. The second and third definitions give the functions for converting from decimal to hexadecimal and from hexadecimal to decimal numbers. Notice that the variable HX$ must be initialized for both of these. The last two statements define the functions for converting from decimal to-octal and from octal to decimal numbers.*

```
1.DEF FN DB#(D)=(D AND 1)+(D AND 2)*5+(D AND 4)*25+
                 (D AND 8)*125+(D AND 16)*625+
                 (D AND 32)*3125+(D AND 64)*15625+
                 (D AND 128)*78125


2.HX$="0123456789ABCDEF"
   DEF FN DH$(D)=MID$(HX$,(D AND -4096)/4096+1-
                 (D>32767)*16,1)+
                 MID$(HX$,(D AND 3840)/255+1,1)+
                 MID$(HX$,(D AND 240)/16+1,1)+
                 MID$(HX$,(D AND 15)+1,1)


3.HX$="0123456789ABCDEF"
   DEF FN H$D(H$)=(INSTR(HX$,MID$(H$,1,1))-1)*4096+
                  (INSTR(HX$,MID$(H$,2,1))-1)*256+
                  (INSTR(HX$,MID$(H$,3,1))-1)*16+
                  (INSTR(HX$,MID$(H$,4,1))-1)


4.DEF FN DO#(D)=(D AND 7)+(D AND 56)*1.25+
                 (D AND 448)*1.5625+
                 (D AND 3584)*1.953125+
                 (D AND 28672)*2.44140625


5.DEF FN O$D(O$)=VAL(MID$(O$,1,1))*3276+
                  VAL(MID$(O$,2,1))*4096+
                  VAL(MID$(O$,3,1))*512+
                  VAL(MID$(O$,4,1))*64+
                  VAL(MID$(O$,5,1))*8+
                  VAL(MID$(O$,6,1))
```

These functions can also be used as subroutines by those without the DEF FN command. An AND-statement is necessary, because it performs a logical-AND operation which is used in all three routines to convert decimal to the various other bases.

The first function, which I call FNDB#, returns the binary equivalent of the argument as an eight-digit integer.

The hexadecimal equivalent of the argument is returned by the second function, FNDH$, as a four-character string with leading zeros. Arguments greater than 32767 (7FFF hexadecimal) must be signed; ie: reduced by 65536. For a 1-byte conversion, only the second half of the function is necessary.

My third function, called FNH$D, converts the argument, which must be a four-character string, into its decimal equivalent. In this function, the INSTR command is employed; if your BASIC does not have it, it is easily replaced with a BASIC subroutine. Its function is to return the position in the first string at which the second string begins. FNH$D can also be made into a 1-byte routine by using its second half. Both FNH$D and FNDH$ require HX$ to be initialized.

The final two functions for decimal-to-octal conversions (FNDO# and FNO$D) work similarly to their hexadecimal counterparts. ■

The Brains of Men and Machines

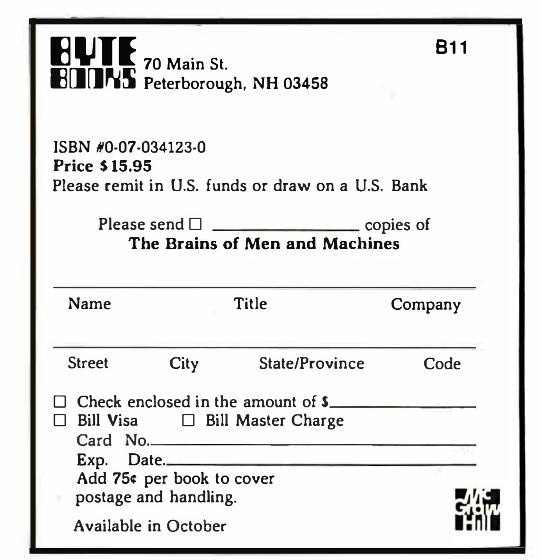
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Three-Dimensional Graphics for the Apple II

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Many articles have been written regarding three-dimensional graphics on home computers. Some involve highly complex hardware such as spinning mirrors, while others rely upon computation-intensive software to project three-dimensional objects on a two-dimensional plane.

Taking an innovative step backwards and rediscovering an old technique, I have been able to create three-dimensional pictures using my Apple II computer. I have generated a number of visually stimulating displays in this manner and would like to share with you the methods used, with the hope that you too will discover new ways to use your computer.

The method is simple. Just take a piece of cardboard, and with a pair of scissors, cut out a pair of eyeglass frames. Next, put a red filter over the left eye opening in the frame and a green filter over the right opening (I did say it was an old idea!). When viewing the screen with the glasses on, anything colored red will not be visible to your right eye, and anything green will not be visible to your left eye (you may have to adjust the tint on your television to optimize this). Anything white will be visible to both eyes.

The image that falls on the retina of your right eye will be the green image on the video monitor, but it will appear to be white! (It's all done in your brain.) The same is true of the red image in relation to your left eye. (We will refer to the red image in our software as violet. This is because the Apple HI-RES graphics cannot generate red.) [*However, see "More Colors for Your Apple," by Allen Watson III, June 1979 BYTE, page 60*...**RSS**]

Creating an Image

As you can see by figures 1a and 1b, an image that seems to appear in front of the screen can be made by drawing the green image to the left of the red one. An image that appears behind the screen is simulated by placing the green image to the right of the red one. The apparent depth is determined by the distance between the two colored images.

It should be mentioned that the brain requires a frame of reference to judge distance "properly." An efficient way to provide this reference is to put a white border around the screen. This will define the *neutral* plane. Naturally, any objects on this plane need be drawn only once in white.

The program in listing 1 generates a set of lines which appear to disappear into the distance.

Another simple program is presented in listing 2. This one generates a three-dimensional box.

Using the shape-generator programs provided by Apple, the user can make objects appear to be various sizes and depths. This effect can be seen by running the program in listing 3.

You can place as many objects in space as you have room for. There are, however, some guidelines.

- You should draw your images from *back* to *front*. This way any overwriting will look natural.
- As you approach the neutral plane, the two images get closer together. Any place that they are coincident should be white. This can be handled with software. (I didn't say easily.)
- Using other colors generates an unbalanced image in the neutral plane—you experiment.
- You will have to adjust your color television set to match the color of the filters that are being used. The best way to do this is to draw a small green square and a small red square on the screen. Then place a

Text continued on page 154

Listing 1: *This Apple integer BASIC program generates three-dimensional lines disappearing into infinity.*

```
  0 XO=YO=COLR=SHAPE=ROT=SCALE
  5 INIT=2048:CLEAR=2062:PLOT=2830:LINE=2836:DRAW=2871:XDRAW=2884
 10 BLACK=0:WHITE=127:VIOLET=85: LET GREEN=42
100 CALL INIT: POKE -16302,0:
150 REM   BUILD THE BORDER
200 COLR=WHITE:XO=0:YO=0: CALL PLOT:XO=279: CALL LINE:YO=191: CALL LINE:XO=0: CALL LINE:YO=0: CALL LINE
205 XO=1:YO=1: CALL PLOT:XO=278: CALL LINE:YO=190: CALL LINE:XO=1: CALL LINE:YO=1: CALL LINE
250 REM
251 REM
252 REM
500 REM  LINES TO INFINITY
510 COLR=VIOLET:XO=25:YO=180: CALL PLOT:XO=260:YO=20: CALL LINE:XO=70:YO=180: CALL LINE
520 COLR=GREEN:XO=60: CALL PLOT:XO=270:YO=20: CALL LINE:XO=10:YO=180: CALL LINE
550 END
```

Listing 2: *An Apple integer BASIC program for generating a three-dimensional box.*

```
  0 XO=YO=COLR=SHAPE=ROT=SCALE
  5 INIT=2048:CLEAR=2062:PLOT=2830:LINE=2836:DRAW=2871:XDRAW=2884
 10 BLACK=0:WHITE=127:VIOLET=85: LET GREEN=42
100 CALL INIT: POKE -16302,0:
150 REM   BUILD THE BORDER
200 COLR=WHITE:XO=0:YO=0: CALL PLOT:XO=279: CALL LINE:YO=191: CALL LINE:XO=0: CALL LINE:YO=0: CALL LINE
205 XO=1:YO=1: CALL PLOT:XO=278: CALL LINE:YO=190: CALL LINE:XO=1: CALL LINE:YO=1: CALL LINE
600 REM
601 REM
602 REM
603 REM  A BOX....
610 COLR=WHITE:XO=150:YO=50: CALL PLOT:XO=250: CALL LINE:YO=150: CALL LINE:XO=150: CALL LINE:YO=50: CALL LINE
615 COLR=GREEN:YO=75:XO=40: CALL LINE
620 XO=140: CALL LINE:XO=250:YO=50: CALL LINE
622 XO=250:YO=150: CALL PLOT
625 XO=140:YO=175: CALL LINE:XO=40: CALL LINE:XO=150:YO=150: CALL LINE:XO=40:YO=175: CALL PLOT
630 YO=75: CALL LINE:XO=140: CALL PLOT:YO=175: CALL LINE
635 XO=41:YO=75: CALL PLOT:YO=175: CALL LINE:XO=141: CALL PLOT:YO=75: CALL LINE
637 COLR=VIOLET
640 XO=30:YO=185: CALL PLOT:YO=85: CALL LINE:XO=130: CALL LINE:YO=185: CALL LINE
642 XO=250:YO=150: CALL LINE
645 XO=130:YO=185: CALL PLOT:XO=30: CALL LINE
650 XO=150:YO=150: CALL LINE:XO=30:YO=85: CALL PLOT:XO=150:YO=50: CALL LINE
660 XO=130:YO=85: CALL PLOT:XO=250:YO=50: CALL LINE
680 END
```

Listing 3: *This program uses the shape stored in the Apple II shape table and transforms it into three-dimensional form.*

```
  0 XO=YO=COLR=SHAPE=ROT=SCALE
  5 INIT=2048:CLEAR=2062:PLOT=2830:LINE=2836:DRAW=2871:XDRAW=2884
 10 BLACK=0:WHITE=127:VIOLET=85: LET GREEN=42
100 CALL INIT: POKE -16302,0:
150 REM   BUILD THE BORDER
200 COLR=WHITE:XO=0:YO=0: CALL PLOT:XO=279: CALL LINE:YO=191: CALL LINE:XO=0: CALL LINE:YO=0: CALL LINE
205 XO=1:YO=1: CALL PLOT:XO=278: CALL LINE:YO=190: CALL LINE:XO=1: CALL LINE:YO=1: CALL LINE
250 REM
700 REM
701 REM
710 REM
800 REM    3-D SQUARES
801 REM   USE SHAPE #1
802 REM  SHAPE #1 = 01 01 24 3F 3F 36 36 2D 2D 24 00
805 ROT=0:SCALE=1:SHAPE=1:XO=5:YO=5
810 FOR I=1 TO 7:SCALE=I:COLR=GREEN:XO=XO+(I*4):YO=YO+(I*4)
820 CALL XDRAW:COLR=VIOLET:XO=XO+I:YO=YO+I: CALL XDRAW: NEXT I
830 XO=XO+32:YO=90:COLR=GREEN:SCALE=SCALE+2: CALL XDRAW:COLR=VIOLET:YO=YO+8:XO=XO+8: CALL XDRAW
840 XO=XO+42:YO=YO-42:COLR=GREEN:SCALE=SCALE+2: CALL XDRAW:COLR=VIOLET:YO=YO+9:XO=XO+9: CALL XDRAW
999 END
```

Editor's Note:
Some Comments on the Programs

The three programs in this article assume that the high-resolution graphics routines have been loaded into the Apple II starting at hexadecimal location C00. The instruction LOMEM:4096 should be executed before loading the programs to protect these routines.

When I was typing these programs into the Apple, I noticed that line 10 of each listing has the statement LET GREEN = 42. At the time I could not understand why the LET keyword was used, so I deleted it. Several syntax errors later I realized the answer.

When "GREEN = 42" is parsed by the BASIC interpreter, the token GR (for graphics mode) is recognized. The rest of the line (EEN = 42) is then unrecognizable to the parser. When "LET GREEN = 42" is analyzed, the keyword LET tells the parser that the next token will be a variable. Therefore, GREEN is not broken into two tokens (GR and EEN).

This little trick could prove very useful when you wish to use a variable name which contains a keyword.



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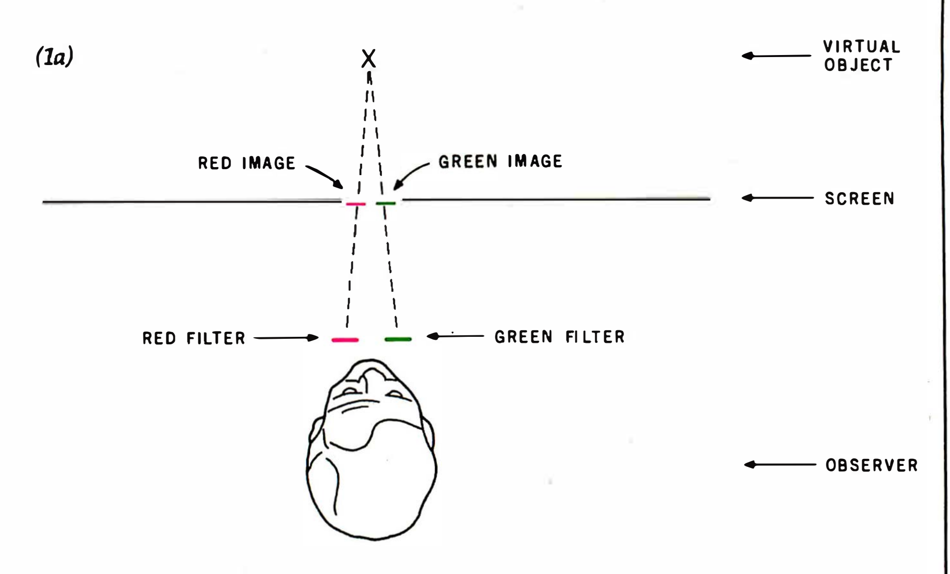
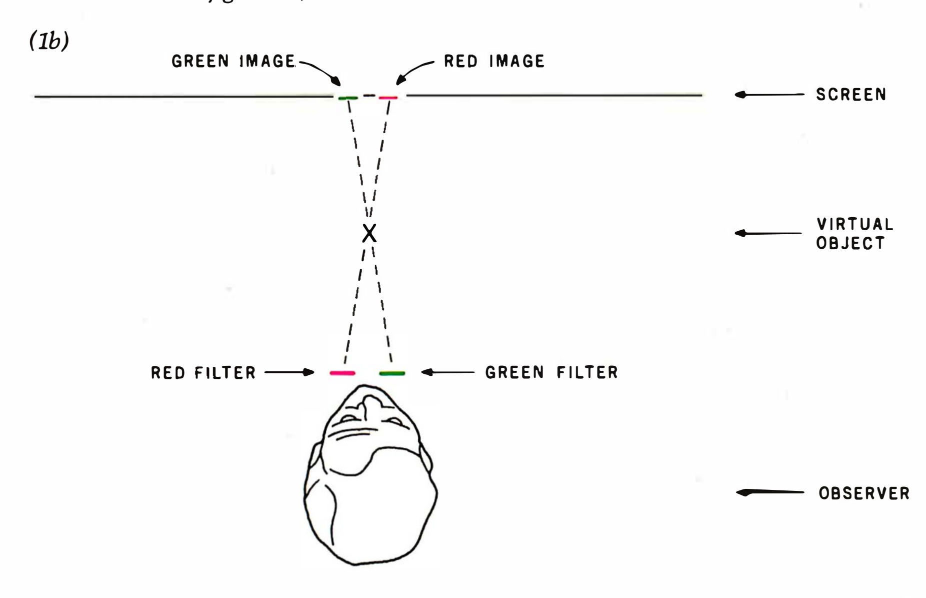


Figure 1: *A figure which appears to be behind the video screen can be produced by drawing the red image on the left side of the screen and the green image on the right side (see figure 1a). By reversing these two images, the image will appear to be in front of the video screen (see figure 1b).*



Text continued from page 148:

piece of the green filter over the red square and a piece of the red filter over the green square. Adjust the tint, chrominance (if you have one), and color knobs so that both squares disappear (as much as possible...you may have to double up the filters).

- If you aren't worried about using your color television for other entertainment, you can make the following adjustments to it. On the back of the set are three controls that are (usually) labeled red, green, and blue (or R, G, B; or red screen, blue screen, green screen). These adjust the relative intensity of the three electron guns. If you first mark the initial positions of the three controls with a pencil, you will be able to reset them when you are finished. The adjustment is simple. Turn the blue screen off! This removes all the blue dots from the screen, only red and green remain. After adjusting the television as described in the previous step, reverse the positions of the filters (red over red, green over green) and adjust the red screen so that the intensity of the two squares through the filters appears the same.
- We used colored cellophane, available at most art supply stores, for filters.

There are a number of games that can be adapted to three-dimensional displays with this technique. Have fun! ■

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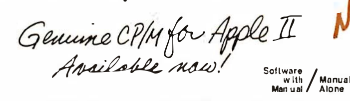
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☐ **CPM/374X**—Has full range of functions to create or re-name an IBM 3741 volume, display directory information and edit the data set contents. Provides full file transfer facilities between 3741 volume data sets and CP/M files .... $195/$10

Coming Soon

CPAids*

☐ **MASTER TAX**—Professional tax preparation program. Prepares schedules A, B, C, D, E, F, G, R/RP, SE, TC, ES and forms 2106, 2119, 2210, 3468, 3903, 2441, 4625, 4726, 4797, 4972, 5695 and 6251. Printing can be on readily available, pre-printed continuous forms, on overlays, or on computer generated, IRS approved forms. Maintains client history files and is interactive with CPAids GENERAL LEDGER II (see below) .... $995/$30
Annual Update Fee $350

☐ **STANDARD TAX**—As above for schedules A, B, C, D, E, G, R/RP, SE, TC and forms 2106 and 2441. Also, does not maintain client history files .... $495/$30
Annual Update Fee $175

☐ **GENERAL LEDGER II**—Designed for CPA's. Stores complete 12 month detailed history of transactions. Generates financial statements, depreciation, loan amortizations, journals, trial balances, statements of changes in financial position, and compilation letters. Includes payroll system with automatic posting to general ledger. Prints payroll register, W2's and payroll checks .... $450/$30

Lifeboat Associates, 1651 Third Avenue, N.Y., N.Y. 10028 **(212) 860-0300** Telex: 220501

Neu in der Schweiz Lifeboat Associates GmbH, Aegeristr. 35, 6340 Baar **Telefon 042/31 2931**

Software with Manual / Manual Alone

New

☐ **T/MAKER**—Powerful new tool for preparing management reports with tabular data. Makes financial modeling projects easy. Do you want a weekly profitability report? Set up the table and compute. Just change the sales figures for next week and compute. You have a new report! T/MAKER includes a full screen editor for setting up tables which pages left, right, up and down. Compute includes standard arithmetic, percents, exponents, common transcendental functions, averages, maxima, minima, projections, etc. Requires 48K CP/M, CBASIC-2, CRT Terminal with addressable cursor positioning .... $275/$25

☐ **BSTAM**—Utility to link one computer to another (M) also equipped with BSTAM. Allows file transfers at full data speed (no conversion to hex), with CRC block control check for very reliable error detection and automatic retry. We use it! It's great! Full wildcard expansion to send *.COM, etc. 9600 baud with wire, 300 baud with phone connection. Both ends need one. Standard and (M) versions can talk to one another. This software requires a knowledge of assembler language for installation. .... $150/$10

☐ **BSTMS**—Intelligent terminal program for (M) CP/M systems. Permits communication between micros and mainframes. Sends character data files to remote computers under complete control. System can record character data sent from remote computer systems and data banks. Includes programs to EXPAND and COMPRESS binary files for transmission. This software requires a knowledge of assembler language for installation. .... $200/$25

☐ **WHATSIT?***—Interactive data-base system using associative tags to retrieve information by subject. Hashing and random access used for fast response. Requires CBASIC-2 .$175/$25

☐ **SELECTOR III-C2**—Data Base Processor to † create and maintain multi-key data bases. (M) Prints formatted sorted reports with numerical summaries or mailing labels. Comes with sample applications, including Sales Activity, Inventory, Payables, Receivables, Check Register, and Client/Patient Appointments, etc. Requires CBASIC-2. Supplied in source .... $295/$20

☐ **GLECTOR**—General Ledger option to SELECTOR III-C2. Interactive system provides for customized COA. Unique chart of transaction types insure proper double entry bookkeeping. Generates balance sheets, P&L statements and journals. Two year record allows for statement of changes in financial position report. Supplied in source. Requires SELECTOR III-C2, CBASIC-2 and 56K system. .... $350/$25

DMA

☐ **CBS**—Configurable Business System is a † comprehensive set of programs for defining custom data files and application systems without using a programming language such as BASIC, FORTRAN, etc. Multiple key fields for each data file are supported. Set-up program customizes system to user's CRT and printer. Provides fast and easy interactive data entry and retrieval with transaction processing. Report generator program does complex calculations with stored and derived data, record selection with multiple criteria, and custom formats. Sample inventory and mailing list systems included. No support language required .... $395/$40

MICROPRO

☐ **SUPER-SORT I**—Sort, merge, extract utility as (L) absolute executable program or linkable module in Microsoft format. Sorts fixed or variable records with data in binary, BCD, Packed Decimal, EBCDIC, ASCII, floating & fixed point, exponential, field justified, etc. Even variable number of fields per record! .... $225/$25

☐ **SUPER-SORT II**—Above available as abso- (L) lute program only .... $175/$25

☐ **SUPER-SORT III**—As II without SELECT/ (L) EXCLUDE .... $125/$25

☐ **DATASTAR**—Professional forms control entry (L) and display system for key-to-disk data capture. Menu driven with built-in learning aids. Input field verification by length, mask, attribute (i.e. uppercase, lower case, numeric, auto-dup, etc.). Built-in arithmetic capabilities using keyed data, constant and derived values. Visual feedback for ease of forms design. Files compatible with CP/M-MP/M supported languages. Requires 32K CP/M .... $350/$35

☐ **WORD-STAR**—Menu driven visual word pro- (L) cessing system for use with standard terminals. Text formatting performed on screen. Facilities for text paginate, page number, justify, center and underscore. User can print one document while simultaneously editing a second. Edit facilities include global search and replace, Read/Write to other text files, block move, etc. Requires CRT terminal with addressable cursor positioning .... $445/$40

☐ **WORD-STAR-MAIL-MERGE**—As above with (L) option for production mailing of personalized documents with mail lists from DATASTAR or NAD .... $575/$40

☐ **WORD-MASTER** Text Editor—In one mode (L) has superset of CP/M's ED commands including global searching and replacing, forwards and backwards in file in video mode, provides full screen editor for users with serial addressable-cursor terminal .... $145/$25

Software with Manual / Manual Alone

New

☐ **MAGIC WAND**—Word processing system with simple, easy to use full screen text editor and powerful print processor. Editor has all standard editing functions including text insert and delete, global search and replace, block move and library files for boiler plate text. Print processor formatting commands include automatic margins, pagination, headings & footings, centered and justified text. Also prints with true proportional spacing, merges with data files for automatic form letters, and performs run-time conditional testing for varied output. Requires 32K CP/M and CRT terminal with addressable cursor. .... $395/$40

☐ **TEXTWRITER III**—Text formatter to justify and (M) paginate letters and other documents. Special features include insertion of text during execution from other disk files or console, permitting recipe documents to be created from linked fragments on other files. Has facilities for sorted index, table of contents and footnote insertions. Ideal for contracts, manuals, etc. Now compatible with Electric Pencil* and Word-Star prepared files .... $125/$20

New

☐ **DATEBOOK**—Program to manage time just like an office appointment book but using the speed and memory of a computer. Keeps track of three appointment schedules (three dental chairs, three attorneys, etc.) at once. Appointments consist of name, reason for the appointment, the date and time, and the length of the appointment. System can be quickly customized for the individual user. Many helpful features for making, changing, finding, and reporting appointments. Requires 48K CP/M and 180K bytes diskette storage. Not available for Apple CP/M. .... $295/$25

New lower prices for application Software

PEACHTREE SOFTWARE*

☐ General accounting software for small busi- (L) nesses. Each product can be used alone or with † automatic posting to the general ledger. Supplied in source for Microsoft BASIC 4.51.

GENERAL LEDGER	$530/$40
ACCOUNTS PAYABLE	$530/$40
ACCOUNTS RECEIVABLE	$530/$40
PAYROLL	$530/$40
INVENTORY	$660/$40

☐ Other application products supplied in source (L) for Microsoft BASIC 4.51.

† MAILING ADDRESS	$530/$40
PROPERTY MANAGEMENT	$925/$40

GRAHAM-DORIAN SOFTWARE SYSTEMS

☐ Comprehensive accounting software written in (L) CBASIC-2 and supplied in source code. Each (M) software package can be used as a stand- † alone system or integrated with the General Ledger for automatic posting to ledger accounts. Requires CBASIC-2.

GENERAL LEDGER	$805/$40
ACCOUNTS PAYABLE	$805/$40
ACCOUNTS RECEIVABLE	$805/$40
INVENTORY SYSTEM	$555/$40
JOB COSTING	$805/$40
APARTMENT MANAGEMENT	$805/$40
CASH REGISTER	$805/$40

☐ **POSTMASTER**—A comprehensive package (M) for mail list maintenance that is completely menu driven. Features include keyed record extraction and label production. A form letter program is included which provides neat letters on single sheet or continuous forms. Includes NAD file translator. Requires CBASIC-2. .... $150/$20

STRUCTURED SYSTEMS GROUP

☐ Complete interactive accounting software for † business. Each product can be used stand-alone or with automatic posting to the general ledger. Each product is thoroughly tested and very well documented. Each product requires CBASIC-2.

GENERAL LEDGER	$820/$40
ACCOUNTS RECEIVABLE	$820/$40
ACCOUNTS PAYABLE	$820/$40
PAYROLL	$820/$40
INVENTORY CONTROL	$820/$40

LIFELINES NEWSLETTER FROM LIFEBOAT

LIFELINES is the first step in software support for the serious microcomputer user. Each issue reports new revisions together with information on the purpose for each such release, be it for correction of "bugs" or the addition of features and facilities.

Feature Articles! New Software! Product Comparisons! Info on CP/M Users Group!

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Software with Manual / Manual Alone

☐ **ANALYST**—Customized data entry and report- † ing system. User specifies up to 75 data items per record. Interactive data entry, retrieval, and update facility makes information management easy. Sophisticated report generator provides customized reports using selected records with multiple level breakpoints for summarization. Requires a disk sort utility such as QSORT, SUPER-SORT or VSORT and CBASIC-2 .... $250/$15

☐ **LETTERIGHT**—Program to create, edit and type letters or other documents. Has facilities to enter, display, delete and move text, with good video screen presentation. Designed to integrate with NAD for form letter mailings. Requires CBASIC-2 .... $200/$25

☐ **NAD** Name and Address selection system—Interactive mail list creation and maintenance program with output as full reports with reference data or restricted information for mail labels. Transfer system for extraction and transfer of selected records to create new files. Requires CBASIC-2 .... $100/$20

☐ **QSORT**—Fast sort/merge program for files with fixed record length, variable field length information. Up to five ascending or descending sort keys. Full back-up of input files created .... $100/$20

CONDIMENTS

☐ **HEAD CLEANING DISKETTE**—Cleans the drive Read/Write head in 30 seconds. Diskette absorbs loose oxide particles, fingerprints, and other foreign particles that might hinder the performance of the drive head. Lasts at least 3 months with daily use. Specify 5" or 8".
Single sided .... $20 each/$55 for 3
Double sided .... $25 each/$65 for 3

☐ **DC 300 Data Cartridges** Specify 450 XL or 300' certified. Pack of 5. .... $100

☐ **FLIPPY DISK KIT**—Template and instructions to modify single sided 5¼" diskettes for use of second side in single sided drives $12.50

☐ **FLOPPY SAVER**—Protection for center holes for 5" and 8" floppy disks. Only 1 needed per diskette. Kit contains centering post, pressure tool and tough 7 mil mylar reinforcing rings for 25 diskettes.

5", Kit	$14.95
5", Rings only	$7.95
8", Kit	$16.95
8", Rings only	$8.95

☐ **PASCAL USER MANUAL AND REPORT**—By Jensen and Wirth. The standard textbook on the language. Recommended for use by Pascal/Z, Pascal/M and Pascal/MT users $12

☐ **THE C PROGRAMMING LANGUAGE**—By Kernighan and Ritchie. The standard textbook on the language. Recommended for use by BDS C, tiny C, and Whitesmiths C users . $12

☐ **STRUCTURED MICROPROCESSOR PROGRAMMING**—By the authors of SMAL/80. Covers structured programming, the 8080/8085 instruction set and the SMAL/80 language $20

☐ **ACCOUNTS PAYABLE & ACCOUNTS RECEIVABLE—CBASIC**—By Osborne/McGraw-Hill $20

☐ **GENERAL LEDGER—CBASIC**—By Osborne/McGraw-Hill $20

☐ **PAYROLL WITH COST ACCOUNTING—CBASIC**—by Osborne/McGraw-Hill $20

Hearty Appetite.

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MAGIC WAND is a trademark of Small Business Application, Inc.
Peachtree Software is a trademark of Retail Sciences, Inc.

†Recommended system configuration consists of 48K CP/M, 2 full size disk drives, 24 x 80 CRT and 132 column printer.

(M) Modified version available for use with CP/M as implemented on Heath and TRS-80 Model I computers.

(L) User license agreement for this product must be signed and returned to Lifeboat Associates before shipment may be made.

(I) This product Includes/eXcludes the language (X) manual recommended in Condiments.

(S) Serial number of CP/M system must be supplied with orders.

(Z) Requires Z80 CPU.

Ordering Information

MEDIA FORMAT ORDERING CODES
When ordering, please specify format code.

LIFEBOAT ASSOCIATES MEDIA FORMATS LIST. Diskette, cartridge disk and cartridge tape format codes to be specified when ordering software for listed computer or disk systems. All software products have specific requirements in terms of hardware or software support, such as MPU type, memory size, support operating system or language.

Computer system	Format Code
Altair 8800 Disk	See MITS 3200
Altos	A1*
Apple - SoftCard 13 Sector	RG
Apple - SoftCard 16 Sector	RR
AVL Eagle	RB
BASF System 7100	RD
Blackhawk Single Density	Q3
Blackhawk Micropolis Mod II	Q2
CDS Versatile 3B	Q1
CDS Versatile 4	Q2
COMPAL-80	Q2
Cromemco System 3	A1*
Cromemco Z2D	R6
CSSN BACKUP (tape)	T1 #
Delta	A1*
Digi-Log Microterm II	RD
Digital Microsystems	A1*
Discus	See Morrow Discus
Durango F-85	RL
Dynabyte DB8/2	R1
Dynabyte DB8/4	A1*
Exidy Sorcerer - Lifeboat CP/M	Q2
Exidy Sorcerer - Exidy CP/M	Q4
Heath H8 - H17/H27	P4
Heath H89 - Lifeboat CP/M	P4
Heath H89 - Magnolia CP/M	P7
Helios II	See Processor Technology
Horizon	See North Star
iCOM 2411 Micro Floppy	R3
iCOM 3712	A1
iCOM 3812	A1*

Computer system	Format Code
iCOM 4511 5440 Cartridge CP/M 1.4	D1 #
iCOM 4511 5440 Cartridge CP/M 2.2	D2 #
IMS 5000	RA
IMS 8000	A1*
IMSAI VDP-40	R4**
IMSAI VDP-42	R4**
IMSAI VDP-44	R5**
IMSAI VDP-80	A1**
Intecolor	See ISC Intecolor
Intel MDS Single Density	A2
Intel MDS Double Density	A5
Intertec SuperBrain DOS 0.1	R7
Intertec SuperBrain DOS 0.5-2.X	RJ
Intertec SuperBrain DOS 3.X	RK
ISC Intecolor 8063/8360/8963	A1
Kontron PSI-80	RF
Meca 5¼"	P6
Micromation (Except TRS-80 below)	A1*
Micropolis Mod I	Q1
Micropolis Mod II	Q2
MITS 3200/3202	B1
Morrow Discus	A1*
Mostek	A1
MSD 5¼"	RC
North Star Single Density	P1
North Star Double/Quad	P2
Nylac Single Density	Q3
Nylac Micropolis Mod. II	Q2
Ohio Scientific C3	A3
Onyx C8001	T2#
Pertec PCC 2000	A1*
Processor Technology Helios II	B2
Quay 500	RO
Quay 520	RP
RAIR Single Density	R9

Computer system	Format Code
RAIR Double Density	RE
Research Machines 8"	A1
Research Machines 5¼"	RH
REX	Q3
Sanco 7000 5¼"	RQ
SD Systems 8"	A1*
SD Systems 5¼"	R3
Sorcerer	See Exidy Sorcerer
Spacebyte	A1
SuperBrain	See Intertec
Tarbell	A1*
TEI 5¼"	R3
TEI 8"	A1*
Thinkertoys	See Morrow Discus
TRS-80 Model I 5¼"	R2
TRS-80 Model I - FEC Freedom	RN
TRS-80 Model I - Micromation	A4*
TRS-80 Model I - Omikron 5¼"	RM
TRS-80 Model I - Omikron 8"	A1
TRS-80 Model I - Shuffleboard 8"	A1
TRS-80 Model II	A1*
VDP-40/42/44/80	See IMSAI
Vector Graphic	Q2
Vector MZ	Q2
Versatile	See CDS Versatile
Vista V80 5¼" Single Density	P5
Vista V200 5¼" Double Density	P6
Zenith Z89 - Lifeboat CP/M	P4
Zenith Z89 - Magnolia CP/M	P7

Prices reflect distribution on 8" single density diskettes. If a format is requested which requires additional diskettes, a surcharge of $8. per additional diskette will be added.

Prices F.O.B. New York. Shipping, handling and C.O.D. charges extra.

Manual cost applicable against price of subsequent software purchase.

The sale of each proprietary software package conveys a license for use on one system only.

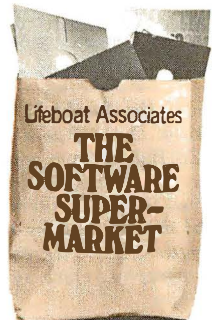
VISA MasterCard

* Single-Side Single-Density disks are supplied for use with Double-Density and Double-Side 8" soft sector format systems.

** IMSAI formats are single density with directory offset of zero.

\# A media surcharge of $25 for order tape formats T1 and T2 and of $100 for orders on disk formats D1 and D2 will be added.

The list of available formats is subject to change without notice. In case of uncertainty, call to confirm the format code for any particular equipment.



Lifeboat Associates
1651 Third Avenue, N.Y., N.Y. 10028
(212) 860-0300

The Altos ACS8000 Single-Board Computer

Mark Dahmke
1515 Superior St, Apt 15
Lincoln NE 68521

Altos Computer Systems of San Jose, California, manufactures a series of powerful Z80-based computers aimed mainly at the small-business and scientific-laboratory markets. The company offers a wide variety of models — from one 8-inch, single-density, Shugart floppy-disk drive with 32 K bytes of main memory to four double-density, 8-inch floppy-disk drives, and a hard-disk subsystem with as much as 58 megabytes of on-line storage.

Hardware Design

The ACS8000 series are all single-circuit-card computers based on a Z80A microprocessor running at 4 MHz. All systems come with at least 32 K bytes of 4116 dynamic memory devices. This is expandable to 64 K bytes on two versions of the ACS8000, and to 208 K bytes on the third version.

The system also comes with a 2708 EPROM (erasable programmable read-only memory) that contains the ALTOS-E monitor program. The 2708 is active until CP/M is boot-loaded: it is then disabled and disappears so the entire memory-address space is available as programmable memory. This technique is widely used and is referred to as "phantom read-only memory."

Serial Ports

Even the smallest Altos system comes with a dual-channel, serial I/O (input/output) device. One channel is used for the system console, and the other is set up to drive a printer or another device, such as a modem. The console channel is preset by the ALTOS-E monitor firmware to 9600 bps, with 1 start bit, 1 stop bit, 8 data bits, and no parity. It runs in full-duplex (ie: simultaneous-bidirectional) mode. The 9600 bps data rate of the console is not alterable, but the printer characteristics can be changed after the system is booted up.

Parallel Ports

All Altos computers come with at least two user-defined parallel ports. There are actually two Z80 PIO (parallel input/output) devices, each with two ports, but one is used to control disk operations. The user-definable ports are accessible through an external connector that may be connected to a printer, an EPROM programmer, or a parallel-input keyboard. Both ports are fully programmable.

The Counter-Timer Circuit

The Z80 CTC (counter-timer circuit) is a programmable counter-timer that has four independent channels. Three of the channels (addresses 0 thru 2) are used by the system to set console and printer data rates and disk-head load-delay times. The fourth channel is available to the user and can be programmed as an interval timer or real-time clock.

The Floppy-Disk Controller

The Altos single-density model uses the Western Digital 1771-1

A Visit to Altos

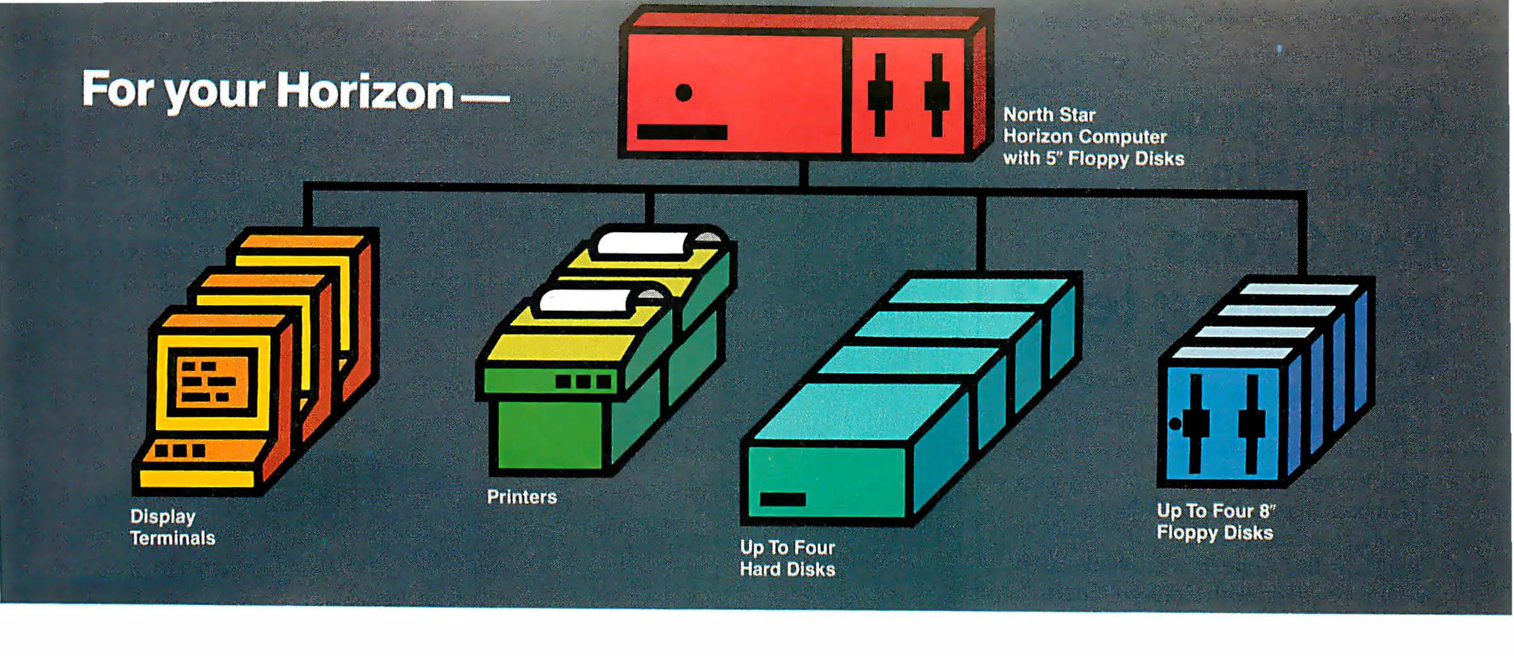
Altos computers have acquired quite a reputation for reliability — it's the sort of thing you hear by word-of-mouth in this industry. To find out more, I paid a visit to Altos recently at the invitation of Dr Roger Vass, the Vice-President of Marketing.

Roger described the extensive quality-control procedures used at Altos, which include several burn-in tests of individual components and complete systems in its testing ovens. Another reason for the low failure rate of the computers (eg: less than 1% are returned to the plant because of defects) is that Altos computers use a single printed-circuit board for the entire computer, thus eliminating many potential interconnection problems.

*Interestingly, Altos sells more computers (ie: about 55% at present) overseas than it does domestically, due in part to the company's vigorous marketing activity in Europe. Roger sees the European market as having great potential for American personal-computer companies. Certainly, the growth of the number of publications and public interest at overseas trade shows confirms this. . .***CM**

About the Author

Mark Dahmke is a a consulting editor for BYTE Publications and also operates a computer consulting business. He has been involved with computers since 1974 and does a great deal of systems hardware and software design. His interests include writing, photography, voice synthesis, and computer graphics.



More power, work, flexibility!

JOEDOS™—Jointly Operate Everything Disk Operating System. Switch from North Star™ BASIC to CP/M™ and back again with a simple command. Floating point and standard 8, 10, 12, and 14 digit precisions of North Star BASIC, as well as Digital Research's CP/M all on the same hard disk unit.

Designed to operate with the DISCUS M26™ 26.5 megabyte (formatted) Winchester-technology hard disk unit and North Star's Micro Disk System, JOEDOS brings you large mainframe performance at microcomputer cost and reliability. CP/M disk activity is amazingly quick through JOEDOS; access to North Star BASIC programs and files is unbelievable!

Speed and enormous storage capacity (as much as 106 megabytes) are only the beginning. Through JOEDOS, each hard disk unit may appear to be one drive or many different "drives" (as many as 147 double density 180K North Star 5¼" drive-size segments). As many as seven of these segmented "drives" may be addressed at any particular time. Segment size, file size and directory size are variable according to user's requirements. Maximum file size is 16 megabytes, while the maximum directory size for each segment is 8,160 entries.

JOEDOS—Micro Mike's hard disk operating system. Requires DISCUS M26 hard disk unit and controller and North Star Micro Disk System for operation. Includes CP/M.
JOEDOS and manual $495

JOESHARE™—North Star Horizon™/DISCUS Hard Disk Timesharing System. Micro Mike's popular interrupt-driven, bank switching timesharing for North Star Horizon computer is now available with all the features of JOEDOS hard disk operating system. JOESHARE allows multiple users to access as many as four 26.5 megabyte hard disk units, simultaneously operating programs through North Star DOS or through CP/M.

JOESHARE—Micro Mike's North Star Horizon timesharing/DISCUS hard disk operating system. Requires North Star Horizon and DISCUS M26 hard disk unit for operation. Includes CP/M.
JOESHARE and manual $750

HDSHARE™—North Star Horizon/North Star Hard Disk Timesharing System. A version of JOESHARE with all of the features of JOEDOS using the North Star hard disk. HDSHARE allows multiple users to access as many as four 18 megabyte North Star hard disk units, simultaneously operating programs through North Star DOS or through CP/M.

HDSHARE—Micro Mike's North Star Horizon timesharing/North Star hard disk operating system. Requires North Star Horizon and North Star hard disk system for operation. Includes CP/M.
HDSHARE and manual $750

5.2SHARE™—North Star Horizon/Floppy Disk Timesharing System. Micro Mike's floppy disk timesharing system has some new enhancements. 5.2SHARE now supports 8, 10, 12, and 14 digit floating point and standard North Star BASIC with as many as four DISCUS 8" drives, operating in conjunction with the Horizon's 5¼" drives to provide in excess of 5 megabytes of external storage.

5.2SHARE—Micro Mike's interrupt-driven, bank switching timesharing for the North Star Horizon computer. Includes 8" drive software interface. For double density or quad capacity systems only.
5.2SHARE and manual $395

DOSCHG™—Micro Mike's 8" drive interface to North Star DOS and BASIC. Requires North Star Micro Disk System and DISCUS 8" drives and controller for operation.
DOSCHG and manual $150

Program operation manuals are available for preview before software purchase.
Program Operation Manuals for each program $25
(Applies toward purchase of program)

Programs are available in double density/quad capacity format only. Prices are subject to change without notice.

Contact your North Star dealer or Micro Mike's.
Send $1 for descriptive literature.

MMike's
Micro Mike's, Inc.
905 South Buchanan Amarillo, Texas 79101 USA Telephone: 806/372-3633
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DISCUS and M26 are registered trademarks of Morrow Designs, Inc.
CP/M is a registered trademark of Digital Research, Inc.

Circle 96 on inquiry card.



Photo 1: *Front view of the Altos ACS 8000-2 computer, which has 64 K bytes of memory and two dual-density, single-sided disk drives.*

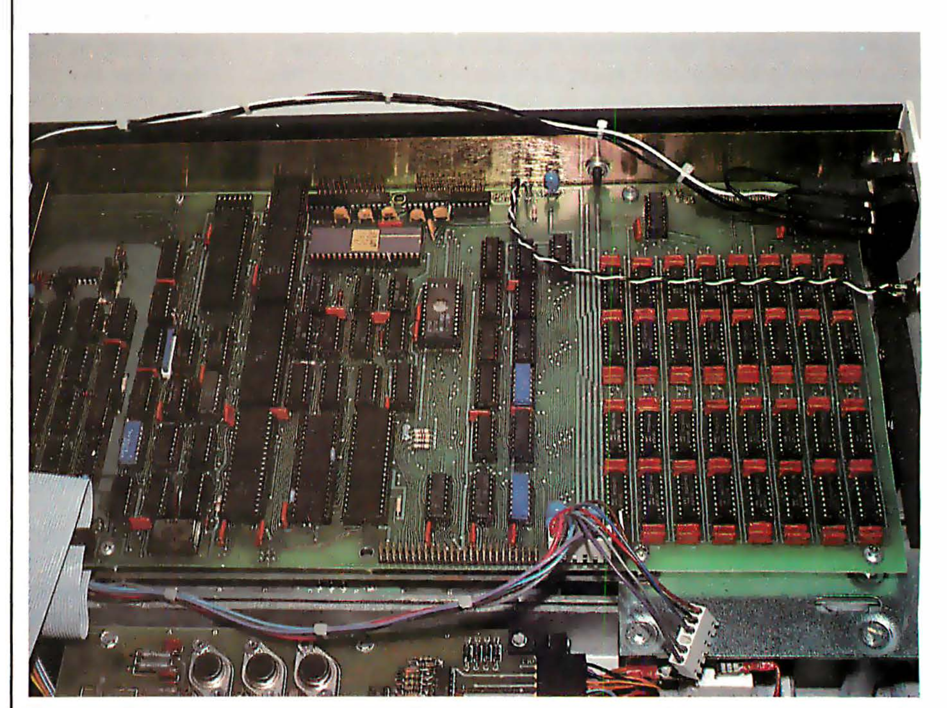


Photo 2: *Interior view of the ACS 8000-2, which is, as are all the Altos models, a single-board, Z80-based computer.*

floppy-disk controller/formatter device to manage up to four 8-inch drives. The 1771-1 is directly integrated into the single-board design of the Altos.

The double-density version requires some additional control circuitry and uses the 1791-1 device; thus the board supporting double-density disks is slightly larger. All versions of the ACS8000 are available with either single-sided or double-sided Shugart drives.

All boards have a fifty-pin expansion connector that allows the user to access all Z80 address, data, and con-


Whatever happened to eenie, meenie, miney, mo?
This may put the Godfather out of business.
I could be another Solomon...
If only my heart would stop racing...
It must use Bayesian, weighted factor analysis, and...
Brilliant! Like a window into the future.
...a perfect gift for that urban cowgirl!
Maybe this'll help me choose a career...
Would I rather have Winston's millions or Billy Joe's love?
I could use it to select my staff.
Hmmmm... could be my ticket to the Boardroom.
Can't any of these people afford $29.95?
Should I buy stock or commodities in this economy?
The decision is...
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trol lines. Altos does not use the connector for expansion purposes because of its single-board philosophy, but it is there for the special needs of the users.

Optional Components

The ACS8000 has provisions for some special components that are optional on all of the standard systems. The Z80 DMA (direct memory access) controller is a very sophisticated device that can be programmed to perform block data transfers from memory to memory, from memory to an I/O port, or vice versa. The device can also be programmed to search for a byte within a block, with or without transfer of the block. The device has one DMA channel that can be set up to work in four different modes:

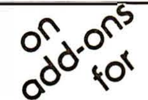
- single-byte mode — in which each memory access operates on a single byte of data
- burst mode — in which the device keeps control of the bus for as long as data is continuously ready
- continuous mode — in which the device retains bus control for the entire operation
- transparent mode — in which the device operates only during memory refresh time so it does not slow down the processor

I was informed by Altos that, although the Z80 DMA device can be plugged into the system, there is no way to use it under CP/M. The OASIS multiuser operating system is set up to use DMA to access a disk, however.

The Advanced Micro Devices Am9511 arithmetic processor is another optional device that provides fixed and floating-point arithmetic and floating-point trigonometric and mathematical operations. It may be used to speed up computational capabilities of the system. All commands and data transfers take place on an 8-bit, bidirectional data bus. Transfers to and from the 9511 may be handled by the Z80 under program control (with IN and OUT instructions) or through the Z80 DMA device. The Am9511 can be programmed to generate interrupts upon completion of arithmetic functions.

Altos also plans to introduce a 2708/2716 EPROM programmer that will plug into the parallel-port con-

Text continued on page 166

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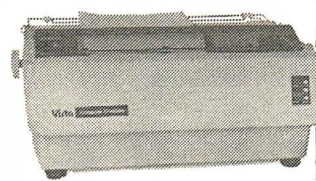
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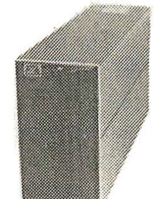
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CP/M Features With Altos Systems

All the standard CP/M system utilities are available:

- *ED: context (text) editor.*
- *ASM: CP/M standard (no-frills) 8080 assembler.*
- *LOAD: loader, converts hexadecimal-ASCII format files to absolute machine-code files.*
- *DDT: CP/M Dynamic Debugging Tool.*
- *PIP: Peripheral Interchange Program that is used to move and copy disk files from disk to disk and can also be used to copy files from disk to printer or from a reader device to disk.*
- *SYSGEN: CP/M utility that generates new system disks.*
- *DUMP: prints the contents of a file on the display in hexadecimal (base 16) form.*
- *SUBMIT: CP/M batch facility: executes a series of console commands from a disk file.*

Some additional commands and utilities are available:

- *MOVCPM: CP/M utility that is used to relocate the CP/M operating system depending on system memory size.*
- *STAT: displays status of various device assignments and shows the amount of free space left on each on-line.*
- *MTS: memory-test program that performs a destructive memory test on system memory.*
- *SETUP: utility that modifies the boot-load sector of a disk. It also allows a disk to be flagged for single- or double-density operation and sets the printer data rate at boot-load time.*
- *REFORM: disk-formatting utility that allows the user to format a disk for single- or double-density operation. Disks may be formatted to be either IBM 3740- compatible or Intel ISIS-II format. Altos has its own format for double density.*
- *DTEST: disk-test utility that checks out both drives and disks on the system.*
- *SINGLE: followed by the letter designation of a drive (A, B, C, D), will set up the drive for single-density operation.*
- *DOUBLE: works the same as SINGLE but sets the designated drive for double-density operation.*
- *COPY: will copy data track by track from the disk in drive A to drive B.*
- *FILES: will display the file-control-block information in hexadecimal for all files on a disk.*

Other files are included with the system:

- *BOOT.ASM: an assembler source for the boot loader.*
- *ALTOSE.ASM: an assembler source for the ALTOS-E 2708 EPROM.*
- *CBIOS.ASM: an assembler source for the custom Basic Input/Output System (CBIOS) in CP/M. This allows the user to make further operating-system modifications as needed.*

UCSD Pascal Operating System

Initializing the System

In order to make UCSD (University of California, San Diego) Pascal fully operational on the Altos, a user-written procedure that does direct cursor addressing on video terminals must be added to the operating system. Referred to as GOTOXY, the procedure accepts two integer variables as input and positions the cursor on the screen accordingly. Since there are so many different video terminals, it is the responsibility of the user to write the GOTOXY procedure. After compiling it, the user must execute a program called BINDER which links GOTOXY to the SYSTEM.PASCAL file.

The other initialization program is called SETUP. When executed, the user is given a set of options including Help and Teach. SETUP modifies a table of key assignments and terminal commands, allowing the user to customize the operating system to a particular terminal. Most keys may also have a prefix (eg: Escape) to allow for terminals that send escape sequences for certain user-definable keys. For example, many terminals have a separate keypad for cursor control (eg: Up, Down, Home, etc). The escape sequence for "cursor home" on many terminals is Escape-H; or 27,72 in decimal ASCII codes. In SETUP, the cursor-home function could be defined as having a prefix code and the decimal value 72 (or H as the character code).

Other Features

The Pascal Operating System has some other unique features. When compiling a program, Pascal will list error messages and ask if you want to continue or return to the editor. If the latter option is chosen, the operating system loads the editor and places the cursor on the character where the compilation error was detected. This feature saves a great deal of time when correcting syntax and logic errors.

The Filer also has some interesting features. Basically, the Filer is a utility program that lists directories of disks and manipulates files directly in the conventional disk-operating-system mode. On request, the Filer will create a duplicate directory for backup purposes. The Filer also has a routine for locating bad blocks on disk. If a bad sector is found, it will be marked as an immovable file in the directory.

Altos is marketing Pascal/M and a C compiler. The firm is also in the process of providing hard-disk backup on cartridge tape. The company is also introducing an asynchronous communications package for Altos computers (price: $100) and a bisynchronous IBM 3780 protocol package that allows the Altos to go on line in batch mode to an IBM host computer. The price is $1000.

In version II.0 of Pascal, the Debugger package is missing. I was informed by Altos that it was having problems with it and that a new version would be available with the next release. Altos also said that Pascal/M does have a full Debug option and that it will be available shortly.

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Text continued from page 162
nector. This project has been delayed because of software development priorities.

Hard-Disk Capability

Altos' third single-board version of the ACS8000 has an on-board hard-disk controller in addition to the floppy-disk controller. Hard-disk storage may start at 14.5 megabytes and can be expanded up to 58 megabytes.

Multiuser Versions

The system that I received was an ACS8000-2 with 64 K bytes of memory and two dual-density, single-sided floppy-disk drives. As described in the literature, the ACS8000-2/MU2 is a two-user system with 112 K bytes of memory and two double-density single-sided drives.

Memory is divided into banks, with a 16 K-byte system area and two or more 48 K-byte user areas. A four-user ACS8000-2/MU4 is the same as an MU2 but with 208 K bytes of memory. The largest non-hard-disk configuration would be an ACS8000-4/MU4 with 208 K bytes of memory for four users and four double-density, double-sided floppy-disk drives.

> All Altos systems run either CP/M or Altos multiuser executive AMEX.

The smallest hard-disk multiuser configuration would be an ACS8000-6/MU2 with 112 K bytes of memory, two double-density, single-sided drives and a one-platter hard disk yielding 14.5 megabytes of space. This system would have four serial I/O ports and two parallel ports.

The largest configuration would be an ACS8000-9/MU4 with 208 K bytes for four users, four double-density, double-sided floppy-disk drives and 58 megabytes of hard-disk space. A total of six serial ports and two parallel ports would be available on the system; these can be used to support four terminals and two other peripherals.

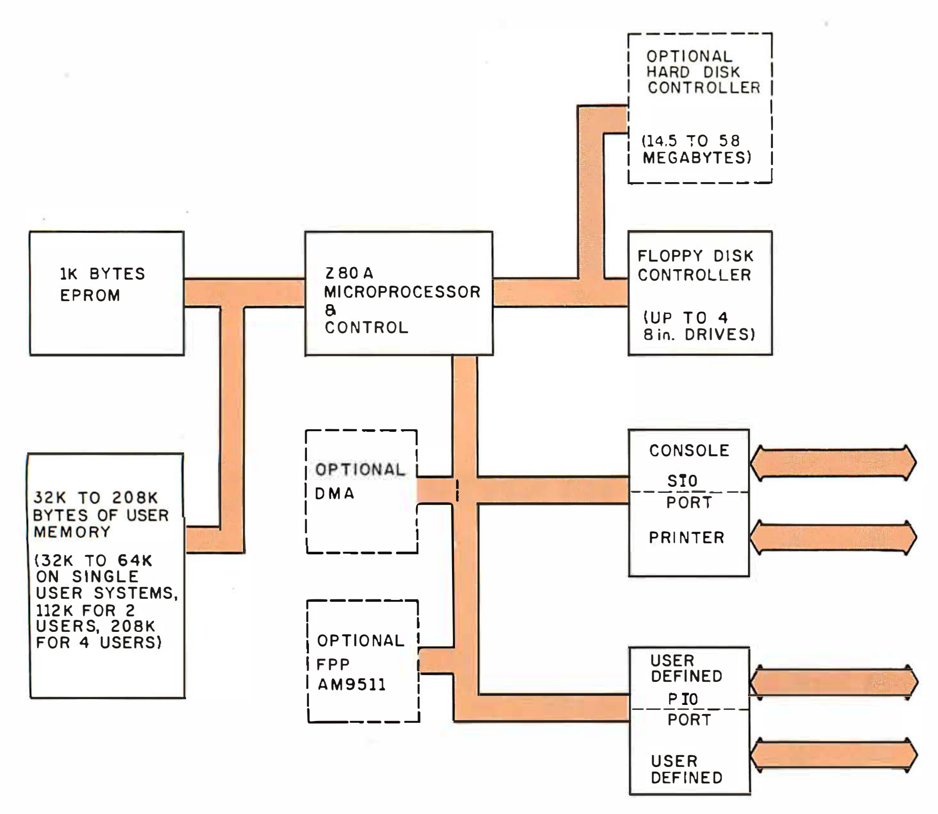


Figure 1: *Block diagram of the Altos ACS8000 systems.*

Software

All Altos systems run either Digital Research's CP/M operating system or Altos multiuser executive AMEX. AMEX is functionally compatible with CP/M, using the same disk formats and operating-system conventions. If you plan to use a hard disk, AMEX is a necessity since straight CP/M supports only floppy disks. CP/M version 2.0, which directly supports hard disks, and MP/M, the multiprogramming version of CP/M, are also available.

Optional Software

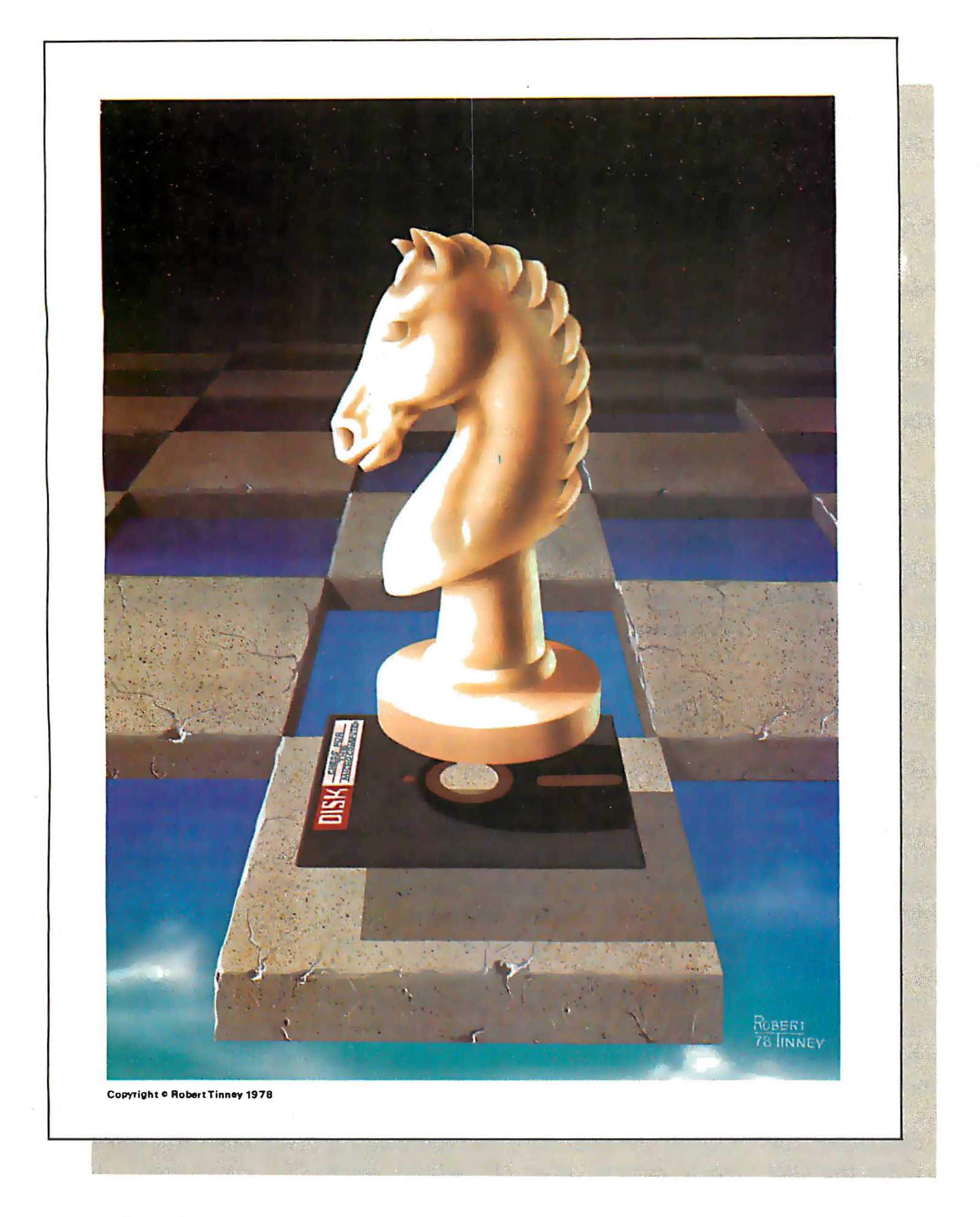
The Altos CP/M has been customized to allow for printout *spooling* and *despooling*. In this process, printed material is stored on disk until the printer is free. This option allows printers to be driven in the background mode so that printing may go on while the computer is doing something else.

Another software option is for use with the Microsoft FORTRAN-80 compiler. A FORTRAN service-subroutine library called APULIB makes use of the Am9511 floating-point processor to speed up arithmetic computations in FORTRAN by a factor of 10 or more. A typical FORTRAN program performing extensive calculations could run about four times faster with APULIB.

The other major software option is the UCSD Pascal operating system. Altos offers it as a separate and distinct operating system for the ACS8000. This operating system consists of a file manager, an editor, a Pascal compiler, a BASIC compiler, a macroassembler for the Z80, an interactive debugger, and a linker/librarian. UCSD (University of California, San Diego) Pascal runs as a P-machine interpreter. All portions of the operating system and some other run-time subroutines are written in Pascal, with the exception of portions of the P-machine interpreter. Pascal is also patched to handle the Am9511 arithmetic processor for greater computational speed. The Z80 CTC is also set up to act like a real-time clock. Unfortunately, the real-time clock is not accessible by the user; it is used internally to improve the performance of the disk interface.

Altos Documentation

The manual shipped with the Altos consists of the following segments:



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- an operating manual which contains a hardware and software overview section
- setup and checkout guides
- a CP/M operating guide
- a troubleshooting section
- all the schematic diagrams

The manual also includes the SA800/801 disk-drive maintenance manual and six publications from Digital Research covering all aspects of CP/M.

Setting Up and Using a New System

My Altos is hooked up to a video terminal set to 9600 bps. When power is applied, the Altos displays the two prompt characters %* on the console, which means that the EPROM monitor is in control. (If reset is depressed, the same response is given.) If a floppy disk is inserted into drive A (the drive on the right-hand side) and reset is depressed, the monitor will automatically begin loading the operating system from the disk. If you are running CP/M, the message "32 K ALTOS DOS VERS 1.47" will be displayed, followed by A> on the next line. The A character means that the disk in drive A is the currently active disk, while the > indicates that CP/M is ready to receive commands.

After the machine displayed the A> prompt, I tried to enter the DIR command to display the directory, with no success. I reset the system and tried again — still nothing. Then I decided to check the RS-232 cable and connectors to see if the transmit and receive lines were hooked up properly. After experimenting with my own 8080-based system to make sure the terminal would talk to it and still finding no problems, I called Altos: the gentleman I spoke with suggested that I make sure that pin 20 (Data Terminal Ready) of the RS-232 cable was hooked up. I took apart my cable and found that pin 20 was not connected. A quick resoldering job solved the problem. (I later discovered that the Altos manual discusses the problem in the section on troubleshooting, but I had apparently not seen it on my first reading of the manual.)

One of my complaints about the Altos is that the console data rate is defined in firmware — in the EPROM. The system can be used only if you have a 9600 bps terminal (at least, to start with). Even after the initial load, there is no way to easily modify the data rate short of creating a new EPROM.

CP/M has a SETUP command that allows the user to change the bootload characteristics of a disk. The printer data rate, the system clock rate (2 MHz or 4 MHz), and the density of the disk may be redefined for each system disk. It would seem reasonable to be able to modify the console data rate also, but this is not currently the case.

Formatting Disks

The next thing I tried to do was to create a backup copy of the master system disk. The documentation for this procedure is fairly accurate, but important instructions are left out.

The first step is to insert a blank disk (with the label side facing down) into drive B, the left-hand drive. The REFORM command will reformat a disk for any of several disk formats. After typing in REFORM, the computer asks you to enter a number corresponding to the type of format that will be used and to indicate whether the blank disk is in drive B (in a two-drive system) or drive D (in a four-drive system).

The first time I tried to format a disk, I got errors on top of errors. The documentation failed to mention that the write protect notch on the disk must be covered to allow read/write operation. Since I usually work with 5-inch floppy disks, I am used to covering the write protect notch to protect a disk, not to unprotect it. After trying everything I could think of, it finally occurred to me that the notch might need to be covered to work. [*This method of disk protection is standard for 8-inch disks, so neither Altos nor its documentation is in error here. Still, this situation*

At a Glance

Name of computer	*Altos ACS8000 series*
Manufacturer	*Altos Computer Systems 2360 Bering Dr San Jose CA 95131 (408) 946-6700*
Price	*from $2840 (ACS8000-1S)*
Processor	*Z80A (8-bit)*
Memory	*64 K bytes (expandable to 208 K bytes on a multiuser system)*
Mass Storage	*one to four 8-inch, single- or double-density, single- or double-sided, Shugart floppy-disk drives*
Other hardware features	*includes serial printer port, two user-definable parallel ports*
Software included	*ALTOS-E monitor (in read-only memory)*
Hardware options	*an 9511 arithmetic-processor board; Winchester hard disk; multiple users*
Software options	*Operating systems: AMEX, CP/M, MP/M, OASIS, UCSD Pascal.*
Languages	*FORTRAN-80; MBASIC, MBASIC-80, CBASIC II; COBOL-80, CIS COBOL; Vanguard APL, PL/I-80, Z80 Macro Assembler*

*always causes problems for people who are accustomed to working with 5-inch floppy disks. . . .***GW**]

Altos Demonstration Programs

The CP/M disk that came with the system had a number of demonstration programs, including a biorhythm program in BASIC, a rather poor implementation of tic-tac-toe, a number-guessing game, and a program that did nothing but compute and print square roots. The business package demonstration programs included a payroll generator and an automobile parts-list/inventory program.

The only documentation provided with any of these business demo programs was a single typed page giving hopelessly inadequate operating instructions. I never succeeded in making any of the nongame programs work.

Final Remarks

- The hardware of the Altos ACS8000 is well designed, although the documentation of some of its components is absent. The computer uses several sophisticated, optional support chips such as the counter-timer, the serial and parallel ports, and the Am9511 arithmetic processor. However I had to look over the manufacturers' specification sheets and application notes to find out anything about them.
- The software of the Altos ACS8000 is not as well supported, but the CP/M, AMEX, UCSD Pascal, and OASIS operating systems are available. Altos has provided no software support for the specialized hardware built into the system.
- Languages available from Altos include FORTRAN-80, MBASIC, MBASIC-80, CBASIC II, COBOL-80, CIS COBOL, Vanguard APL, PL/I-80,. and Z80 Macro Assembler. Numerous other languages are available from other sources for use with the CP/M operating system.
- The Altos ACS8000 is strong on hardware and weak on software and documentation. Perhaps someday the Altos people will get around to documenting and supporting the best selling points of their product line. ■

Seventh Annual SIGGRAPH Conference

Kenneth Livingston
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University of Nebraska
Lincoln NE 68508

Mark Dahmke
1515 Superior, Apt 15
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The Association for Computing Machinery (ACM) Special Interest Group on Computer Graphics (SIGGRAPH) held its seventh annual conference on July 14 thru 18, at the Seattle (Washington) Center (former site of the Seattle World's Fair). This conference, like all of the recent SIGGRAPH conferences, was extremely well attended. Over 1200 people registered for the two-day preconference tutorials. More than 2300 people registered for the three-day conference itself. Participants came from nearly every state, Canada, several European countries, and Japan.

Preconference Tutorials

Each year, the conference organizers have sought to provide participants with an opportunity to not only attend the conference, but also to acquire additional information and expertise about graphics through a series of tutorial sessions. These are led by well-known computing and graphics professionals from both industry and education. This year's eight tutorial sessions included these topics:

- Introduction to Computer Graphics
- Introduction to Raster Graphics
- Advanced Raster Graphics
- Computer-Aided Design
- Low-Cost Graphics
- Graphic Design and Information Graphics
- Animation Graphics
- User Interfaces to Graphic Systems

These tutorials ranged in level of expertise from novice to expert and provided a means for everyone to advance technically.

The session on low-cost computer graphics addressed issues relating to the use of graphics capabilities of personal-computing hardware. Many of these systems can be configured at costs of about $2000. Given today's economy, systems in this price range can be very appealing to small businesses, public-school systems, and small colleges and universities. At the other end of the scale are large CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) systems. Typically, these systems are quite expensive, ranging from $40,000 to $300,000 for top-of-the-line systems. Obviously, smaller and less expensive (and, therefore, less comprehensive and versatile) systems exist. The computer-aided design tutorial addressed the needs of medium- and large-scale industry users of CAD/CAM systems.

Included in this session were discussions of CAD/CAM standards for data bases and techniques used for geometric modeling. Geometric modeling is a term used to describe the process of representing a three-dimensional object by a series of Cartesian, polar, or homogeneous coordinates with (or without) a series of equations. The object may or may not exist prior to the construction of the numerical or geometric model.

Three other tutorials on raster graphics and animation were oriented toward the use of raster-scan devices. Because raster-scan devices essentially use standard television technology, there is a significant price and performance advantage in their use. Personal-computer owners should be aware of this advantage, as many microcomputer systems have utilized raster-scan (television) technology from the beginning. Discussions of algorithms for modeling three-dimensional objects, simulation of light sources (shading and shadows), surface textures, and display optimization dominated these sessions. An emphasis was placed on the creation of realistic-looking images.

Another group of tutorials centered on what might be termed *human factors* in computer graphics. Human factors means the interface between human beings and machines. It is an area of computing in general that, while not being totally overlooked, has certainly been slighted. Those of us involved in interactive computing (including graphics) realized long ago, by necessity, how important a friendly, forgiving, and possibly even *natural* interface is for successful communication between people and machines. The frustration of having an interactive program bomb or hang before completing its task can be overwhelming.

Our batch-oriented colleagues have discovered this recently, primarily because on-line data bases are becoming more popular, and more batch-oriented computing professionals are finding their way into interactive projects. Recently, we have begun to discover the importance of aesthetically pleasing and more understandable graphic output. Many computer-graphics specialists have come into this area from the technical side, rather than from the artistic side. It should come as no surprise, then, that graphic designers can offer much sound advice about graphics layout and design. This information can be very valuable in businesses where executives are accustomed to expecting and demanding professional quality for graphics presented at board meetings and in annual reports. Two tutorials concentrated on psychological aspects, design methodologies, subjective evaluation, and design concepts as they relate to computer-graphics systems.

All of the tutorials were well attended. Although we were unable to attend all of them (they ran concurrently), those sessions we attended were well thought out and carefully presented.

Photos 1 thru 6 by Kenneth Livingston.

The Conference

In an attempt to emphasize the importance of graphic-design concepts and the human-factors side of computer graphics, the first session was a special panel presentation chaired by Aaron Marcus, research consultant at Lawrence Livermore Laboratories. This panel featured graphic designers from the United States and Europe. They agreed that we have seen far too many examples of poorly designed graphics—especially computer-generated graphics. Anyone engaging in computer graphics would do well to obtain and read some good textbooks on graphic design, in addition to their computer-graphics texts. While a chart or graph is more understandable than a table of numbers, a well-designed chart or graph is more readable than one which has had no design principles applied to its creation.

The remainder of Wednesday's sessions were split into two concurrent sessions. Papers presented in one group of sessions were quite technical in nature: "The Theory, Design, Implementation and Evaluation of a Three-Dimensional Surface Detection Algorithm" and "Simulation and Expected Performance Analysis of Multiple Processor Z-Buffer Systems." Papers presented in the other group of sessions were more applications-oriented: "Geographic and Data Base Systems" and "Computer Graphics Moves into the Business World."

The latter area is of specific interest to one of us (Livingston), who is currently involved in the integration of computer graphics and market research. According to Carl Machover of Machover Associates, who chaired the business-graphics panel discussion, there are four computers used in business applications for every computer used in CAD/CAM types of applications. Assuming that these figures are accurate, the business-computer graphics potential is enormous. This position is supported by IBM's recent entry into the low-cost, color, business-graphics marketplace with its Model 3279 display terminal. Recent articles in *Harvard Business Review* (January 1980) and the *Wall Street Journal* also seem to reinforce this position.

Thursday's sessions embraced a wide variety of topics. Sessions dedicated to graphics software and languages, surfaces, and applications filled the morning. Papers were presented at these sessions ranging from the design of a LISP-based graphics language, to three-dimensional representation and rendering algorithms, and to stereographic displays of atmospheric data. (This latter session proved to be very interesting to us for reasons having little to do with computer graphics. The materials chosen for displays represented conditions existing in the Omaha, Nebraska, area—sixty miles away from our homes—when the 1975 tornado struck that area.)

Thursday-afternoon sessions were oriented toward rather specialized areas of computer graphics:

- Computer Graphics and Television
- Animation
- CAD/CAM
- User Views of CAD/CAM

Recent uses of computer graphics in television were discussed, including a presentation by ABC Sports on their use during the Winter Olympics. The CAD/CAM sessions included reports on graphics used in planning electrical-distribution systems, ship-hull design, and graphics at the Ford Motor Company. There was also a panel discussion addressing productivity gains and expectations achieved through the use of CAD/CAM systems.

Friday's sessions included discussions of graphics standards, human factors (more), and raster techniques. The question of graphics standards is of particular importance to those who regularly attempt to transport graphics programs or systems from one computing environment to another. While other areas of computing developed standards long ago (eg: COBOL, FORTRAN, Pascal, etc), the graphics area had not attempted such a feat until quite recently. This has all begun to change, thanks to the work of the SIGGRAPH CORE standards committee.

The human-factors presentations included discussions on color and how it is perceived by the human eye, and on a prototype voice- and gesture-input interface being developed at MIT. An afternoon session on raster-graphics techniques completed the conference program.

Perhaps the only negative criticism we offer concerns the famous SIGGRAPH film festival. This has become an annual event since its informal inception, at the first SIGGRAPH conference, on the balcony of one participant's dormitory room at the University of Colorado in Boulder. This year's film festival was held in a hotel ballroom designed to hold no more than 1500 people. With 1900 people packed into the crowded space, and lines waiting to get in, the hotel's management restricted access to the ballroom for safety reasons. A greatly abbreviated second showing left many participants frustrated. The film festival is a forum for some of the best computer graphics and animation produced during the preceding year and is always enlightening and well attended. We sincerely hope next year's conference committee takes the film festival's popularity into consideration during planning.

The Exhibition

Although this was the seventh annual SIGGRAPH conference, it was only the fifth annual SIGGRAPH exhibition. There were ninety-nine vendors listed in the exhibition guide for SIGGRAPH '80. At SIGGRAPH '76 (the first exhibition), there were only ten. This says much about the growth of this part of the industry. Another indicator of growth, according to Ken Anderson of the *Anderson Report* (a newsletter devoted to computer graphics), is the fact that last year the computer-graphics industry reached $1 billion in delivered products. The computing industry as a whole does approximately $40 billion in delivered products per year.

Several vendors at the exhibition were of special interest to personal-computer users. ABW Corporation demonstrated its TEKSIM package. TEKSIM allows the Apple II user to access the Tektronix Plot-10 software. Although the Apple/TEKSIM combination offers only about one-fourth the resolution of a Tektronix terminal, advantages such as lower cost, color displays, selective erase, and standard video output are claimed by the vendor. Apple Computer Inc displayed both the Apple II and III computers. Calcomp, which most of us think of as a vendor for the large-host user, demonstrated its 1051 drum plotter (among other products). The Model 1051 is an RS-232C-compatible, relatively low-cost product, which, considering Calcomp's quality reputation and service organization, makes it a viable product for passive-graphics production on small systems.

Cromemco, with which most personal-computer users are familiar, brought its line of high- and medium-resolution graphics hardware to the exhibition. Recent

emphasis on efficient software designed to increase the productivity of the programmer and end user is evident in Cromemco's recently announced high-resolution graphics-software package. Digital Engineering, Inc, was present with its Retro-Graphics printed-circuit board. This transforms the Lear-Siegler ADM-3A terminal into a graphics terminal compatible with the Tektronix Plot-10 software package. This company also makes a cross-hair graphic-input cursor and a printer for the modified terminal. Houston Instruments, a division of Bausch & Lomb Corporation, displayed much of its pen-plotter line and its more recently developed electro-static plotter line.

An eight-color, eight-pen digital plotter was displayed by Soltec Corporation. This is an interesting approach to low-cost, multipen, passive graphics. The plotter is basically a single-pen plotter with "parking stalls" for additional pens and enough native intelligence to relocate each pen for changes in color and line weight, or for an optional cross-hair cursor for digitizing. Summagraphics exhibited its popular Bit-Pad One, a low-cost approach to graphic-data-entry problems.

Tektronix was present with nearly everything in its line of graphics terminals and its stand-alone 4050 series of desk-top graphics computers. Hewlett-Packard also displayed its line of desk-top graphics computers including the Model 9845C color machine. The space-shuttle image on this machine was very impressive.

Also present were vendors oriented toward heavy

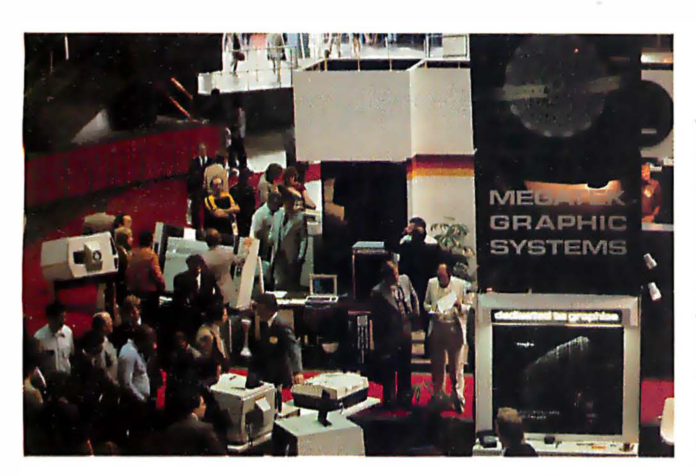


Photo 1: *Megatek's new Wizzard color terminal. It also heralds the development of Megatek's device-independent software.*

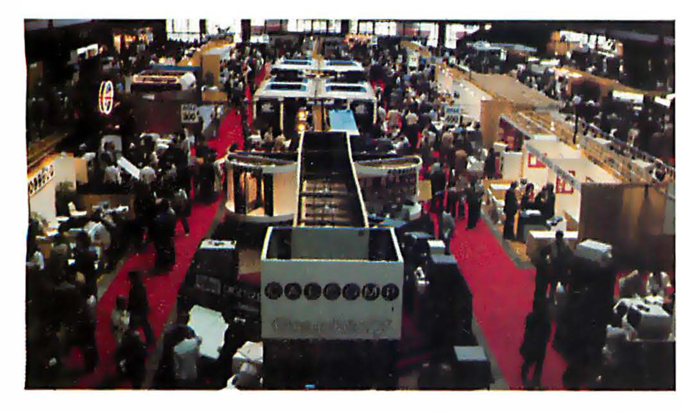


Photo 2: *Overview of exhibition area. The Calcomp booth is in the center foreground. Tektronix is in the center mid-way back. IBM and Hewlett-Packard are in the center rear and Megatek is to the right in the foreground.*

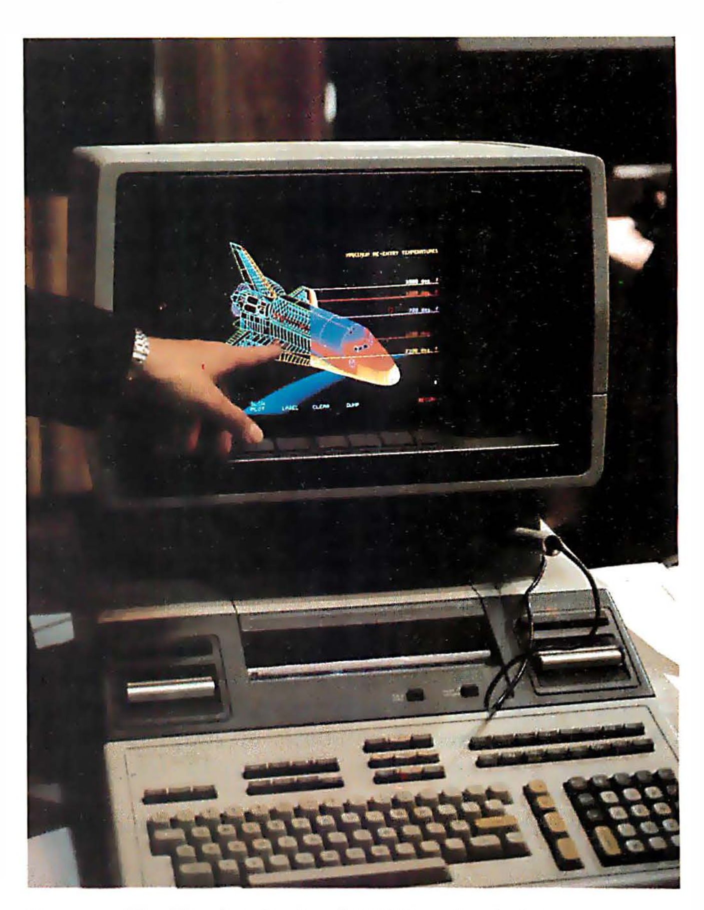


Photo 3: *The Hewlett-Packard 9845C color desk-top computer is being demonstrated by using an image of the space shuttle.*

graphics users. CAD/CAM applications by Computervision, Inc, were shown. IBM showed entries for all levels: the 3279 color terminal for low- to mid-level business-graphics users, the 3277 graphics-attachment feature for the mid-level engineering users, and the 3250 for CAD/CAM applications. Vector General and Adage featured their high-performance vector-display devices. Megatek, with a popular display booth, exhibited its new line of Wizzard graphics terminals.

With nearly 100 vendors displaying recent developments, it is not possible to describe all the new products. Suffice it to say that there was something for everyone at the exhibition. If too little information could be gleaned from vendor representatives at their display booths, many vendors also conducted forum sessions from morning until evening. Technical and management people were there to answer more detailed questions about their products.

There are three things we want to reemphasize as being significant in the computer-graphics industry:

- First, the continued development of lower-cost color graphics terminals—the user's capital expenditures are critical in justifying new approaches in problem solving.
- Second, an increased emphasis on graphics-software standards yielding greater productivity for software developers and end users.
- Finally, the beginning use of computer graphics by and for management, as opposed to its historically limited use as an engineering tool.

These items are very important to the growth of the computer-graphics industry. This exhibition, the conference, and the tutorials were dedicated to enhancing these three areas.

Harvey Kriloff and Robert Ellis, cochairmen of the SIGGRAPH '80 conference, and the SIGGRAPH '80 committee are to be commended for the quality of this year's conference. Next year's conference will be held in Dallas, Texas, and is scheduled for August 3 thru 7. Somehow we expect it to be hotter than the 75 degrees of Seattle. If present trends hold up, however, it will also be a fine and interesting conference. ■

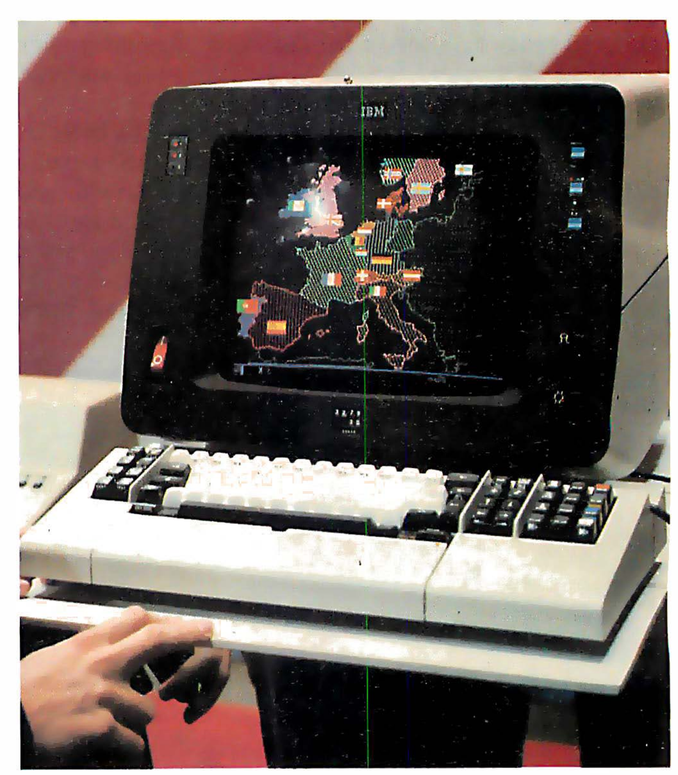


Photo 5: *IBM's Model 3279 color-graphics terminal. This terminal is oriented toward business and management graphics rather than toward engineering applications.*



Photo 6: *The Tektronix Model 4054 features a large-screen storage display tube and built-in cartridge-tape drive, with disk drives optional.*

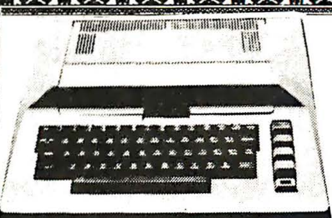
Photo 4: *A Calcomp representative demonstrates the Model 1051 digital plotter.*

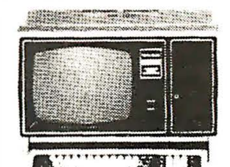
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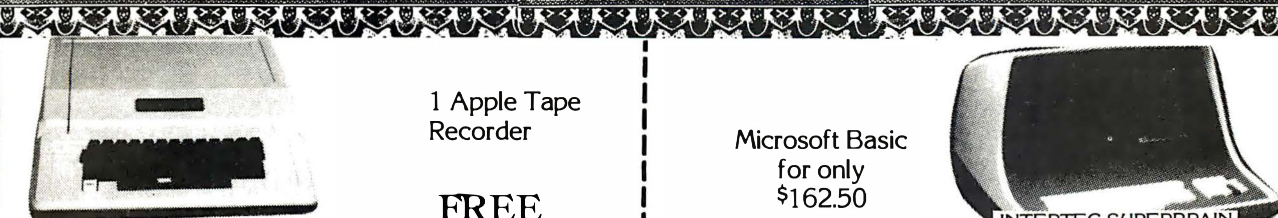
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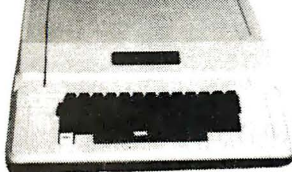
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First of all, The Imagination Machine has 9K RAM and 14K BASIC-IN-ROM. A full 53-key professional, typewriter keyboard. A high-resolution picture on your TV set, in eight colors. Fast loading (1500+ baud rate), built-in dual-track cassette deck, for APF's digitally recorded tape programs. Built-in sound synthesizer. And, even a built-in RF modulator, which is a $40 option on other computer systems.

All that, plus user-programmability.

We know sophisticated users aren't going to be satisfied forever using preprogrammed software. (Even though we offer a large library of educational, entertainment, home and business management programs.) So, we made The Imagination Machine user programmable, in both BASIC and MC6800 machine language. To simplify matters, we've just developed the first and only BASIC TUTOR course on cassette. With it, you can learn to program The Imagination Machine in BASIC, with hands-on training, right at the computer.

Some exceptional features.

The Imagination Machine has several unique features that can help you use your time at the computer more effectively.

For example, it stores programs and data on the same cassette tape. (With other computers, you have to read programs from one tape into the computer, remove the tape, put in another tape and store your data on the new tape.)

Another special feature is The Imagination Machine's unique keyword system, which simplifies BASIC programming. The machine has 24 different programs statements and commands printed at the top of the keyboard. You can enter these 24 into your program without retyping them every time you use them. Instead of typing out "PRINT," for example, you just press two keys and the word appears on the screen. The system helps prevent typing errors and can speed up entering programs.

A third feature is Timed Response Monitoring, which automatically adjusts the computer's pace and level to your own. It makes "tutoring programs," for instance, easier and more interesting to follow.

And then there are The Imagination Machine's three graphic display modes: 1. Alpha numerics, mixed with low-resolution graphics in as many as eight colors. 2. High resolution — up to eight colors — 128 x 192 display. 3. High resolution graphics — up to four colors — with 256 x 192 display.

And expandability.

A personal computer that can't grow along with your growing requirements soon becomes obsolete. So, we designed The Imagination Machine to be expandable. By adding APF's optional "Expansion Box" and interface cartridges, you can hook up any compatible floppy disk or printer, or an additional 8K RAM memory cartridge.

Full mini-floppy system $995.



For small business and professional use, you may require a full mini-floppy system. In that case, order APF's System II. It includes The Imagination Machine, the "Expansion Box," floppy disk interface and 72K-byte, mini-floppy disk drive. All for just $995! No one can come close to that price.

You can't beat our prices or our guarantee.

If you can find a better personal computer system for the money, let us know. In the meantime, we stand by our statement: There is no other personal computer on the market that offers so much for so little. And if you order now, we'll even include our $19.95 APF Technical Reference Manual, with complete schematics, absolutely free.

Order The Imagination Machine directly from APF Electronics, with the assurance that if you are not completely satisfied, you can return it within 30 days of purchase for a complete refund. To order, or to learn the name of the dealer nearest you, call TOLL FREE 1-800-223-1264. New York residents call 212-869-1960. MasterCard and VISA accepted.

Price list:

System I, The Imagination Machine.	$599.
System II, Mini-floppy System (Includes The Imagination Machine, BB-2, and Mini-floppy Disk Drive).	$995.
BB-1. Expansion Box with RS232 cartridge.	$199.95
BB-2. Expansion Box with floppy disk interface cartridge.	$199.95
8K RAM memory cartridge.	$ 99.95
RS232 cartridge.	$149.95
Floppy-disk interface cartridge.	$149.95
Mini-floppy Disk Drive.	$399.95

$599. Manufacturer's suggested retail price.



Circle 107 on inquiry card.

A Simplified Theory of Video Graphics

Part 1

Allen Watson III
1261 Robbia Ct
Sunnyvale CA 94087

This is an interesting time for choosing a personal computer, especially if you are looking for one with a graphics display. As you can see from the summary of specifications in table 1, the available graphics capabilities of the personal computers are all different, and no one model has a clear advantage over all the others. To make your choice even more difficult, some models exhibit undocumented quirks that are not apparent from the specifications.

Your choice of a video-graphics system will depend on what you want to do with graphics and on the performance of the different computers. While I can't help with the first aspect of your decision, I may be able to help you understand system performance by explaining the operating principles of video displays and describing the various combinations of features available on popular personal computers.

The Importance of Video Graphics

Many applications of personal computers are modeled on conventional practices that have been developed over a period of several years, while graphics displays have been too expensive for general use until quite recently. Many existing computer programs do not use even the simplest graphics, although there are several notable exceptions, such as chess games that use high-resolution graphics to display the board and pieces, and music editors that display standard musical notation.

Here's the important point: computer-graphics displays can produce schematic diagrams, music scores, flowcharts, architectural drawings, and the like that are much easier for the person using the computer to understand than the unadorned columns of numbers that are usually associated with computers. Of course, you still might not be able to afford video-graphics displays as powerful as the one used by NASA to simulate the view seen by the pilot of the space shuttle during its return from orbit. Even though they have their limitations, the current small-computer displays will enable you to do a lot of interesting things.

Raster-Scan Video

While there are several different ways of displaying information on a video screen, all of the personal computers presently available use the same kind of *raster-scan* technique that ordinary television does. We'll take a look at the basic features of this technique, since they are shared by all inexpensive video displays.

Television is an imperfect compromise among several factors:

- resolution, which determines how much detail we can display
- frame rate (to be discussed later), which is the number of complete pictures transmitted in 1 second
- bandwidth, a measure of the frequency response, of the equipment involved

An increase either in resolution or in frame rate requires an increase in bandwidth, which adds to the cost of the equipment. If we must keep within a limited bandwidth, we can obtain better resolution only at the expense of jerkier motion and vice versa. There is a type of television called *slow-scan*, for example, that manages to transmit reasonably detailed images over the narrow-bandwidth channels used by amateur radio operators, but the resulting frame rate is so low that the illusion of motion is lost. We will see how much bandwidth is necessary for ordinary television after we look at the raster-scan process itself.

If we display a sequence of images that change only slightly from one to the next, and do it fast enough, the eye will not be able to separate them: *persistence of vision* will cause the separate images to fuse into a "moving" picture. In order to transmit such a sequence of images electronically, each image must be dissected into a series of dots that may be transmitted one at a time. The television camera does this by rapidly scanning the image in a series of horizontal lines which form a *raster*. The lines are scanned one after another in the same way that a person scans the lines of letters on a printed page. Reading is a process of converting information,

About the Author

Allen Watson III began writing FORTRAN programs for scientific analysis soon after receiving his bachelor's degree in mathematics. Later, as a full-time programmer, he wrote IBM System/360 assembly-language programs for the computer-aided design of calculators and has prepared and presented training courses about the Fairchild F-8 and Motorola 6800. Allen is currently writing and editing user manuals for Apple computers.

Start learning and computing for only ***$129.95*** *with a Netronics 8085-based computer kit. Then expand it in low-cost steps to a business/development system with 64k or more RAM, 8" floppy disk drives, hard disks and multi-terminal I/O.*

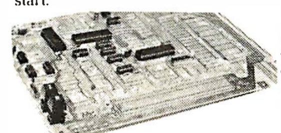
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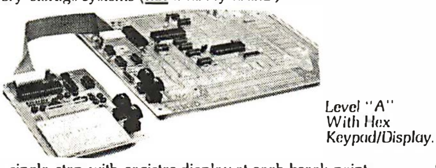
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Full 8" disk system for less than the price of a mini (shown with Netronics Explorer/85 computer and new terminal). System features floppy drive from Control Data Corp., world's largest maker of memory storage systems (not a hobby brand!)



Level "A" is a complete operating system, perfect for beginners, hobbyists, industrial controller use. $129.95



Level "A" With Hex Keypad/Display.

LEVEL "A" SPECIFICATIONS

Explorer/85's Level "A" system features the advanced Intel 8085 cpu, an 8355 ROM with 2k deluxe monitor/operating system, and an advanced 8155 RAM I/O . . . all on a single motherboard with room for RAM/ROM/PROM/EPROM and S-100 expansion, plus generous prototyping space.

PC Board: Glass epoxy, plated through holes with solder mask. • **I/O:** Provisions for 25-pin (DB25) connector for terminal serial I/O, which can also support a paper tape reader . . . cassette tape recorder input and output . . . cassette tape control output . . . LED output indicator on SOD (serial output) line . . . printer interface (less drivers) . . . total of four 8-bit plus one 6-bit I/O ports. • **Crystal Frequency:** 6.144 MHz. • **Control Switches:** Reset and user (RST 7.5) interrupt . . . additional provisions for RST 5.5, 6.5 and TRAP interrupts onboard. • **Counter/Timer:** Programmable, 14-bit binary. • **System RAM:** 256 bytes located at F800, ideal for smaller systems and for use as an isolated stack area in expanded systems . . . RAM expandable to 64K via S-100 bus or 4k on motherboard.

System Monitor (Terminal Version): 2k bytes of deluxe system monitor ROM located at FØØØ, leaving ØØØØ free for user RAM/ROM. Features include tape load with labeling . . . examine/change contents of memory . . . insert data . . . warm start . . . examine and change all registers . . . single step with register display at each break point, a debugging/training feature . . . go to execution address . . . move blocks of memory from one location to another . . . fill blocks of memory with a constant . . . display blocks of memory . . . automatic baud rate selection to 9600 baud . . . variable display line length control (1-255 characters/line) . . . channelized I/O monitor routine with 8-bit parallel output for high-speed printer . . . serial console in and console out channel so that monitor can communicate with I/O ports.

System Monitor (Hex Keypad/Display Version): Tape load with labeling . . . tape dump with labeling . . . examine/change contents of memory . . . insert data . . . warm start . . . examine and change all registers . . . single step with register display at each break point . . . go to execution address. Level "A" in this version makes a perfect controller for industrial applications, and is programmed using the Netronics Hex Keypad/Display. It is low cost, perfect for beginners.

HEX KEYPAD/DISPLAY SPECIFICATIONS

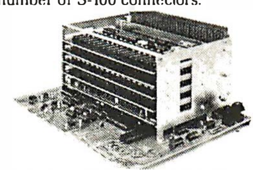
Calculator type keypad with 24 system-defined and 16 user-defined keys. Six digit calculator-type display, that displays full address plus data as well as register and status information.

LEVEL "B" SPECIFICATIONS

Level "B" provides the S-100 signals plus buffers/drivers to support up to six S-100 bus boards, and includes: address decoding for onboard 4k RAM expansion selectable in 4k blocks . . . address decoding for onboard 8k EPROM expansion selectable in 8k blocks . . . address and data bus drivers for onboard expansion . . . wait state generator (jumper selectable), to allow the use of slower memories . . . two separate 5 volt regulators.

LEVEL "C" SPECIFICATIONS

Level "C" expands Explorer/85's motherboard with a card cage, allowing you to plug up to six S-100 cards directly into the motherboard. Both cage and card are neatly contained inside Explorer's deluxe steel cabinet. Level "C" includes a sheet metal superstructure, a 5-card, gold plated S-100 extension PC board that plugs into the motherboard. Just add required number of S-100 connectors.



Explorer/85 With Level "C" Card Cage.

LEVEL "D" SPECIFICATIONS

Level "D" provides 4k of RAM, power supply regulation, filtering decoupling components and sockets to expand your Explorer/85 memory to 4k (plus the original 256 bytes located in the 8155A). The static RAM can be located anywhere from ØØØØ to EFFF in 4k blocks.

LEVEL "E" SPECIFICATIONS

Level "E" adds sockets for 8k of EPROM to use the popular Intel 2716 or the TI 2516. It includes all sockets, power supply regulator, heat sink, filtering and decoupling components. Sockets may also be used for 2k x 8 RAM IC's (allowing for up to 12k of onboard RAM).

DISK DRIVE SPECIFICATIONS

- 8" CONTROL DATA CORP. professional drive.
- LSI controller.
- Write protect.
- Single or double density.
- Data capacity: 401,016 bytes (SD), 802,032 bytes (DD), unformatted.
- Access time: 25ms (one track).

DISK CONTROLLER/ I/O BOARD SPECIFICATIONS

- Controls up to four 8" drives.
- 1771A LSI (SD) floppy disk controller.
- Onboard data separator (IBM compatible).
- 2 Serial I/O ports
- Autoboot to disk system when system reset.
- 2716 PROM socket included for use in custom applications.
- Onboard crystal controlled.
- Onboard I/O baud rate generators to 9600 baud.
- Double-sided PC board (glass epoxy.)

DISK DRIVE CABINET/POWER SUPPLY

- Deluxe steel cabinet with individual power supply for maximum reliability and stability.

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Beginner's Pak (Save $26.00!)— Buy Level "A" (Terminal Version) with Monitor Source Listing and AP-1 5-amp Power Supply: (regular price $199.95), now at SPECIAL PRICE: **$169.95** plus post. & insur.

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Computer Model	Text: Lines by Characters	Method	Graphics: Resolution	Aspect Ratio	Color: No. of	Method
Apple II	24 by 40	Subcell Mapping	40 by 48 280 by 192	4:3 4:3	16 6	NTSC NTSC
Atari 400 and 800	24 by 40	Subcell Mapping	160 by 80 280 by 192	8:5 4:3	16 4	NTSC NTSC
Commodore PET	25 by 40	Special	320 by 200	4:3	--	----
Compucolor II	32 by 64	Subcell	128 by 128	4:3	8	R-G-B
Exidy Sorcerer	30 by 64	Special	512 by 240	4:3	--	----
Radio Shack TRS-80	16 by 64	Subcell	128 by 48	4:3	--	----
Texas Instruments TI-99/4	24 by 32	Special	256 by 192	4:3	16	NTSC

Table 1: *A summary of some of the features available in personal computer displays. The graphics capabilities of available personal computers differ, and no one model seems to have a clear advantage. NTSC (National Television System Committee) indicates that American-standard color-video conventions are used. R-G-B indicates that separate red, green, and blue video signals are sent to the monitor.*

which is actually all present on the page simultaneously, into a sequence of words that follow one another in time. In a similar fashion, the raster-scan process converts a picture into a sequence of rapidly changing signal levels which represent the brightness of successive points on each scanning line.

When this rapidly changing signal is picked up by a television-receiving set, it is converted back into a visible raster on the screen of the picture tube. The neck of the picture tube contains an *electron gun* that projects a beam of electrons onto a thin layer of phosphor on the inside of the screen. Wherever the electron beam strikes the phosphor it produces a spot of light whose brightness depends on the intensity of the signal being received.

If the electron beam is swept across the screen so that the spot of light is always in the same relative position as the scanning dot in the camera, the picture will be recreated on the screen. The circuits in the television set controlling the position of the beam must be able to keep in step with the camera, so the picture information is interrupted for a short time at the end of each line (and for a longer time at the end of each frame). During these intervals the signal is changed to an intensity level that is never used for picture information, thus creating *synchronization pulses* that the television circuits can distinguish from the picture signal.

In this country, the repetition rate for the picture-scanning process was set at 60 scans per second so that interference from the 60 Hz AC power line will be synchronized; that is, any visible interference effect will stand still on the screen and be less noticeable than it would be if it were moving. Scanning the entire picture 60 times per second amounts to a lot of information per unit of time, and thus requires a very wide bandwidth. The television designers discovered that they could cut the bandwidth requirement in half by making the camera scan every other line during alternate scanning cycles called *fields*. Two successive fields cover all the lines in the raster 30 times each second, to make a *frame*. (See figure 1.) Since the lines of the two alternate fields mesh between each other, this technique is called *interlaced scanning*.

This seems like a rather complicated way of getting 30 frames per second, and you may be wondering whether television wouldn't work just as well with a straightforward scan of the entire raster, 30 times per second. This concept is fine as far as the 60 Hz power-line interference is concerned, but 30 frames per second is too slow for the human eye to merge the image into a continuous picture without noticeable flicker. If you are familiar with filmed motion pictures, you know that they are projected at only 24 frames per second, but a shutter interrupts each frame so that the effective flicker rate is actually 48 frames per second, fast enough for motion to appear continuous.

There are other factors which also

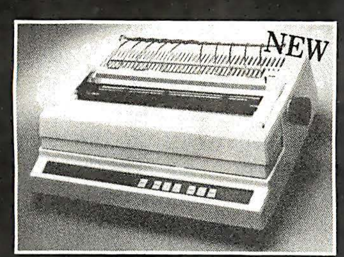
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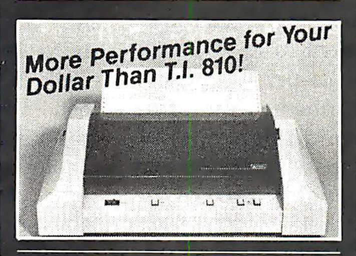
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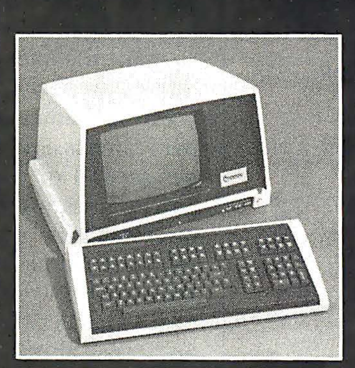
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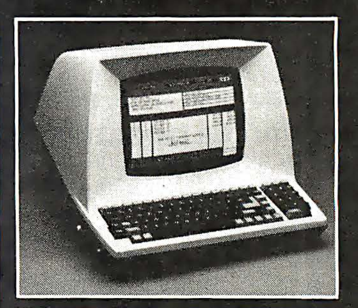
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- Insert/delete line, insert/delete character.
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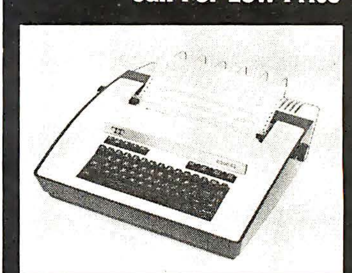
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- Insert/delete line, insert/delete character, line/page erase.
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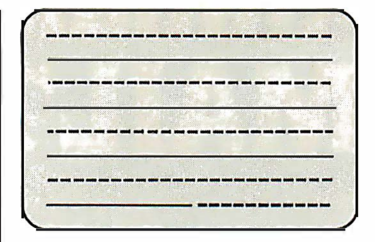


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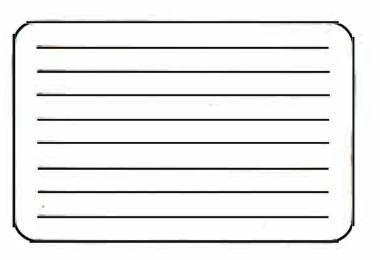


Figure 1: *A comparison of the interlaced (1a) and noninterlaced (1b) raster-scanning schemes. The standard home television receiver displays a picture made up of two alternating fields, each composed of 262½ lines. The lines are interlaced to produce a high-resolution picture that can be transmitted on a narrow bandwidth signal.*

complicate video-display timing. The *vertical-retrace interval* provides time for the television circuits to return the scanning dot to the top of the screen after each field has been completed. Since no picture information should be viewed during this time, the electron beam must be turned off or *blanked*: so, this time is also called the *vertical-blanking interval.*

A complete frame consists of two field scans and two vertical-retrace intervals. Television in the United States uses a total of 525 lines per frame or 262.5 lines per field. Each vertical retrace uses 21 lines, leaving 241.5 lines per field for the transmission of picture information. The odd half-line per field is necessary in order to make the lines of alternate fields interlace properly.

At 30 frames per second, 525 lines per frame is equivalent to 15,750 lines per second or 63.5 μs per line. Since all the lines are scanned in the same direction, the scanning dot must be returned across the screen between the end of one line and the start of the next. This is called *horizontal retrace* and takes about 15 μs.

Video Monitor Versus the Standard Receiver

So that the engineers at the television station can monitor the quality of the signal that is being transmitted, the picture is displayed on a *video monitor* (something like a television set without the antenna and tuner). It does not pick up other television broadcasts but is connected directly to the station equipment generating video signals. If the outgoing video signal already has the horizontal and vertical synchronizing pulses, it is called *composite video*. Most video monitors are also capable of accepting the video signals and synchronizing signals separately.

Because the monitor gets the signal before it has been through the various distortions imposed on it by the transmission and reception equipment, the picture displayed on a monitor is much sharper than the one on a home television set. The bandwidth of the video signal displayed by a home set is limited to less than 4.5 MHz, while most video monitors can handle 12 MHz or more.

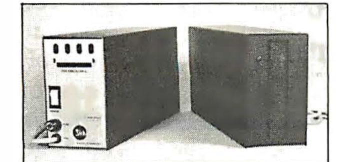
Home television receivers display less of the picture in another respect: they crop off the edges by generating a raster which is too large for the screen. This deliberate *overscanning* is done so that the unavoidable errors in the positioning of the raster (caused by manufacturing tolerances and changes in the power-line voltage) will not leave unsightly gaps at the edges of the picture. In television broadcasting, no important activity is allowed to occur near the edges of the picture where it might be lost. Personal computers that use standard television receivers for their displays must have similar precautions: data is never displayed on the parts of lines near the sides of the screen, or anywhere on the top or bottom lines.

The television signal is transmitted over the air after it is impressed onto a VHF (very-high-frequency) or UHF (ultra-high-frequency) radio signal by *modulation*. Modulation is the modification of some characteristic of the VHF or UHF signal, or *carrier*, in step with the changes in the information that is being transmitted. The particular frequency used for the carrier determines which channel you tune your TV set to in order to pick it up. Circuits in the television can detect the changes in the carrier and extract the information they contain: specifically, the composite-video signal.

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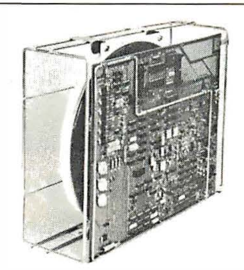
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dinary television set, we must either modify the set internally to give it a direct composite-video input, like that of a video monitor, or else we must add a *modulator* to our computer. The modulator acts like a tiny broadcasting station; it generates a VHF or UHF carrier that corresponds to a standard television channel (which is not being used by a local transmitting station) and modulates it with the computer video signal. The modulated signal can then be connected to the receiver's antenna terminals.

Displaying Computer Data

For our computer to produce a display on a television set or a video monitor, it must generate a composite-video signal. Generating the horizontal and vertical synchronizing pulses is relatively easy, since they just repeat over and over in a fixed numerical relationship. Our computer's internal clock can serve as a stable high-frequency source for a few additional circuits to use in producing the horizontal and vertical synchronizing signals.

> Combining functions helps to keep the cost of personal computing down.

To make the display circuits in personal computers simpler and less expensive, the whole complicated business of interlaced scanning lines and alternating fields has been eliminated in most cases. Instead, the odd half-line per field, which would have been needed to make the field lines interlace, is omitted; this leaves 262 lines per field. Without the interlace, the lines of any two successive fields appear in exactly the same places, so we can just as well think of a computer display as having 60 frames per second, with 262 lines per frame. In fact, a different number of lines per frame may be used if the designer finds it convenient, but the number must be within a few percent of 262 for the display to work with a standard television set.

Video Refresh

While synchronization is easy, generating a video signal with our computer is a little more difficult. First of all, a television picture must be continually regenerated by repeating the entire scanning process 60 times per second. This continual regeneration of the display is called *video refresh*; it requires a stream of data at a rate much too fast for our computer to keep up with—if the system had to compute the data anew for every scan. Instead, most computer designers set aside enough memory to store all of the data that will appear on the display. This reserved memory is called the *video-refresh memory*. Circuits designed especially for video-displaying read data from the refresh memory, in step with the video-synchronizing pulses, and transform the data into the video signal which is displayed.

Using part of the computer's own memory for video refresh has not been the general rule. Most large computer systems include video terminals that are independent of the main computer and contain their own

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The EPROM monitor allows you to display, alter, and search memory, do inputs and outputs, and boot your disk. Debugging aids include register display and change, single stepping, and execute with breakpoints.

The set includes a serial port with programmable baud rate, four independent programmable 16-bit timers (two may be combined for a time-of-day clock), a parallel in and parallel out port, and an interrupt controller with 15 inputs. External power may be applied to the timers to maintain the clock during system power-off time. Total power: 2 amps at + 8V, less than 100 ma. at + 16V and at -16V.

86-DOS™, our $195 8086 single user disk operating system, is provided without additional charge. It allows functions such as console I/O of characters and strings, and random or sequencial reading and writing to named disk files. While it has a different format from CP/M, it performs similar calls plus some extensions (CP/M is a registered trademark of Digital Research Corporation). Its construction allows relatively easy configuration of I/O to different hardware. Directly supported are the Tarbell and Cromemco disk controllers.

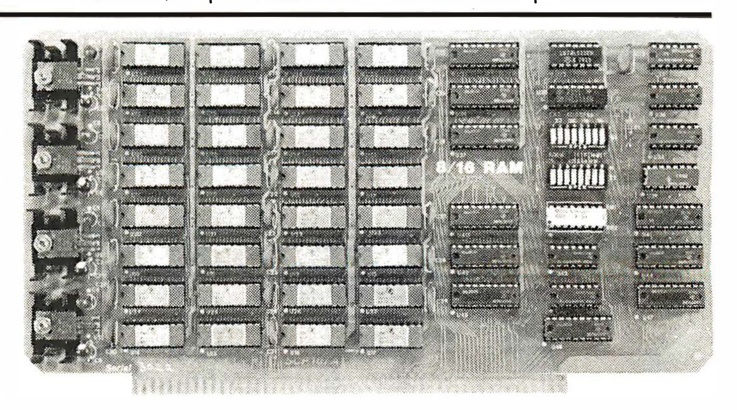
The 86-DOS™ package includes an 8086 resident assembler, a Z80 to 8086 source code translator, a utility to read files written in CP/M and convert them to the 86-DOS format, a line editor, and disk maintenance utilities. Of significance to Z80 users is the ability of the translator to accept Z80 source code written for CP/M, translate this to 8086 source code, assemble the source code, and then run the program on the 8086 processor under 86-DOS. This allows the conversion of any Z80 program, for which source code is available, to run on the much higher performance 8086.

BASIC-86 by Microsoft is available for the 8086 at $350. Several firms are working on application programs. Call for current software status.

All software licensed for use on a single computer only. Non-disclosure agreements required. Shipping from stock to one week. Bank cards, personal checks, CODs okay. There is a 10-day return privilege. All boards are guaranteed one year — both parts and labor. Shipped prepaid by air in US and Canada. Foreign purchases must be prepaid in US funds. Also add $10 per board for overseas air shipment.

8/16 16-BIT MEMORY

This board was designed for the 1980s. It is configured as 16K by 8 bits when accessed by an 8-bit processor and configured 8K by 16 bits when used with a 16-bit processor. The configuration switching is automatic and is done by the card sampling the "sixteen request" signal sent out by all S-100 IEEE 16-bit CPU boards. The card has all the high noise immunity features of our well known PLUS RAM cards as well as "extended addressing". Extended addressing is a replacement for bank select. It makes use of a total of 24 address lines to give a directly addressable range of over 16 megabytes. (For older systems, a switch will cause the card to ignore the top 8 address lines.) This card ensures that your memory board purchase will not soon be obsolete. It is guaranteed to run without wait states with our 8086 CPU set using an 8 Mhz. clock. Shipped from stock. Prices: 1-4, $280; 5-9, $260; 10-up, $240.





Circle 113 on inquiry card.

refresh memory. In other words, a small personal computer is a hybrid: part computer, part terminal. Combining functions in this way helps to keep the cost of personal computing down. Also, putting the refresh memory into the computer makes changing the display faster and easier.

Bit-Mapped Displays

There are several different methods of transforming the data stored in the refresh memory into an effective video display. The most straightforward method is to take the data just as it is read from the refresh memory and transmit it to the display 1 bit at a time. Each 1 bit in this serial bit stream appears on the screen as a spot of light, and each 0 bit as darkness. The size of the refresh memory is matched to the picture scan so that for each bit in the refresh memory there is one spot on the display screen. A one-to-one correspondence of this kind is called a *map*, and this technique for generating computer video displays is called *bit mapping*. An example of a bit-mapped display is shown in photo 1.

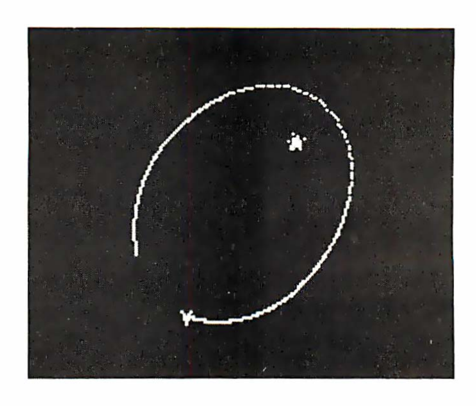


Photo 1: *Example of a bit-mapped display. This simulation of a spaceship in orbit around a star is done on a 180-bit by 150-bit map.*

Since we can program the computer to store data bits into the refresh memory in any pattern we desire, this kind of display can have all the versatility we want, but there are some drawbacks. For one thing, this system requires a large refresh memory. To store a display which is 200 dots high by 300 dots across, for example, takes 60,000 bits or 7500 bytes. Bit-mapped displays are relatively slow, too; just storing 0s into this much memory in order to clear the screen to black takes close to 1 second with the fastest microprocessor.

Displaying only letters and numbers means we can get by with a much smaller refresh memory than is needed for bit mapping. A letter that occupies eight rows of eight dots requires 8 bytes of memory in the bit-mapped display, but we can encode the same letter in ASCII (American Standard Code for Information Interchange) and reduce the size of the refresh memory by a factor of 8. This means that instead of sending the data bits directly to the display, it is necessary to decode each stored character and generate the appropriate video information. To do this, the refresh circuits send the character code (along with signals that indicate which of the eight rows of dots is currently being displayed) to another circuit called a *character generator*. The character generator is little more than a read-only memory that contains the video bit patterns for each of the characters we want to display.

Having a smaller refresh memory more than compensates for the additional cost of the character generator. For example, our 200-dot by 300-dot display has a capacity of 925 characters, in twenty-five rows of thirty-seven characters each. The bit-mapped memory needed for this is 7500 bytes, but we can store 925 characters in only 925 bytes if we use the character generator. It takes only one-eighth as long to update the refresh memory, too. The main drawback is its lack of versatility; we can only display characters of a fixed size and spacing. Obviously, a method of getting many different shapes without increasing the size of the refresh memory would be more flexible.

Using a byte of memory for each character, in all possible combinations of 8 bits, requires a total of 256 different codes. A complete set of uppercase and lowercase letters, numbers, and punctuation takes only ninety-six codes, leaving 160 combinations that we can assign to special shapes useful for graphics. Each special shape must be designed using the same number of dots and rows as the other characters. It may often be necessary to use several of them to make up the image of one object in the display. We can allow for this by setting up special characters such as

straight-line segments, corners, intersections, and so on, in various orientations.

Several personal-computer manufacturers have taken this approach. While keeping the speed and small refresh memory of the character-generator-based design, they also have a reasonable graphics capability with good resolution. To compensate for the limited number of special shapes that you can have with this method, the Exidy and Texas Instruments computers have *programmable* character generators so that you can design your own shape characters and change them as needed.

Character Subcells

There is another way to add graphics capability to the character-generator display. Suppose we divide each of the character cells into four subcells, each of which is four dots square. By displaying any combination of these four subcells, with all dots illuminated, there will be sixteen possible shapes which we can display in each character location. By allocating sixteen extra character codes to represent these sixteen combinations, we can have a very versatile graphics system; however, it won't have much resolution. Dividing each character in half horizontally and vertically converts the twenty-five rows of thirty-seven characters in our example to a 50-block by 74-block graphics display.

We could increase the resolution by dividing the character cells into smaller pieces, but the number of combinations of blocks we would have to encode would increase very quickly. If we divide each cell by 4 in each direction, we increase the resolution to 100 by 148; but, there will be sixteen subcells in each character cell so we must store 16 bits of data for each cell. Since there are 65,536 different 16-bit codes, using read-only memory for the character generator becomes impractical. Instead, it is necessary to devise some logical method for generating the subcell patterns by decoding an extra byte of information, using additional circuitry. Also, the refresh memory would have to be twice as big to store these 2-byte codes. This may help to explain why the personal computers that use this approach have relatively low resolution. ■

The Power of VisiCalc

Robert E Ramsdell
POB 59
Rockport MA 01966

At a Glance

Software:	*VisiCalc*
Type:	*Screen-oriented matrix calculator for projections, budgeting, and many other numeric/data manipulations*
Author:	*Software Arts Inc*
Distributor:	*Personal Software Inc, 1330 Bordeaux Dr, Sunnyvale CA 94086, (408) 745-7841*
Price:	*$150.00*
Format:	*5-inch floppy disk*
Language:	*Machine language*
Computers:	*Apple II, Apple II+ or Apple III; Radio Shack TRS-80, Model I or II; Atari 800; Commodore PET and CBM computers, minimum 32 K bytes of programmable memory required, 48 K or more recommended*
Documentation:	*Loose-leaf binder with eighty-page tutorial manual, reference card*
Audience:	*Businessmen, accountants, attorneys, real-estate investors — anyone who needs to use a calculator for determining options available under different scenarios*

Introduction

The most exciting and influential piece of software that has been written for any microcomputer application is VisiCalc. I've been using VisiCalc almost full-time for the past six months and have written over 300 applications (which I refer to as models) for the program. During that time I have learned its strengths and weaknesses and have found that the authors have allowed for a tremendous number of variables and contingencies in its operation. The instant communication between the operator and the screen facilitates and enhances the manageability and interactivity of the program.

Since I am a certified public accountant, the majority of applications I have written are oriented towards accounting, a usage for which VisiCalc is particularly appropriate. In addition, I know of several attorneys who are using the program for estate- and gift-planning, one of whom is maintaining his accounts receivable, as well, on VisiCalc. A number of real-estate agents are using it to perform real-property investment analysis.

About the Program

VisiCalc is an electronic scratch sheet that is sixty-three columns wide (lettered A thru BK) and 254 rows long (numbered 1 thru 254). Any column/row coordinate can be referred to by any other column/row coordinate arithmetically or trigonometrically. Once the relationships between the coordinates have been established in the model, a change in any value which affects other values will be instantly updated. This gives the computer operator the ability to play instant what-if situations with the value in the matrix.

The program has a great deal of flexibility in its formatting, allowing any coordinate to be a label or a value, and allowing columns to be adjusted from three characters to full-screen width. The screen can be split into two windows, either horizontal or vertical, and each can be scrolled independently of the other. This makes the comparison of information extremely easy. Values can be formatted as full-decimal notation (up to eleven significant digits), two-place decimal (for financial usage), and integer.

An annoyance that I have found in the program is its inability to round off integers, which causes columns to add up imperfectly. This often creates the need for a great deal of additional work when attempting to prepare financial information directly from the model.

One of the most powerful features of VisiCalc is its ability to replicate an entire series of coordinate functions with a few keystrokes. When creating models with a series of identical calculations (such as a 10-year business forecast), only the calculations for the first column must be entered. Then the subsequent columns can replicate the same calculations (VisiCalc automatically uses the new coordinates) in a matter of seconds. This is a tremendous time-saving device when elaborate models are being created. The authors of VisiCalc have also provided the ability to insert, delete, and move entire rows and columns. This feature is useful if the model is finished and

About the Author

Robert E Ramsdell, CPA, is a microcomputer consultant who lives and works in Rockport, Massachusetts. His company, Pansophics, Ltd, published federal income tax models for 1979 and 1980 using VisiCalc and markets several other financial modeling packages.

the user discovers that an important calculation was omitted.

VisiCalc can be interfaced through most printers, and various printer configuration routines are set up directly through the program. The program will output to a printer with any number of character widths, so the choice of printer depends on the needs of individual users. Finally, the methods by which the program loads, saves, and deletes models on the disk are very well designed.

Specific Applications

Accounting applications abound for VisiCalc. Financial analysis, business forecasts, and projections which formerly required hours can be completed with VisiCalc in a matter of minutes. The pricing on a bill-of-materials inventory can be updated in a matter of seconds. Productions estimates can be updated instantly. Different scenarios can be examined and variables and constants interchanged until a workable model is achieved. Even with the advent of programmable electronic calculators, the complexity of forecasting (due to the interdependency of the variables) has limited the accountant to either the most rudimentary forecast or the extremely expensive alternative of time-sharing on a large computer.

Sophisticated and statistically valid time-series analysis can be performed on VisiCalc. Lead and lag regression analysis becomes as easy as entering the various formulas. Each of the variables can be changed or updated, and the results of the new analysis will be instantly displayed.

Small businesses will also find uses for VisiCalc. A model can be created which will allow for the printing of a financial statement whenever a trial balance is entered. Financial ratios and analysis are easily performed. The model can even calculate income tax and compare the current results with those of a previous period or a budget. (Some marketed models even print out tax returns.) Also, budgets are relatively easy to prepare (thanks to the replicate command), and changes and updates are easily entered.

More complex models can be designed for areas such as real estate and stock market investment analysis, where many interdependent variables must be given consideration. A change in any of these variables will instantly cause the entire model to be updated, and new comparisons can be made.

Documentation

VisiCalc comes with an eighty-page tutorial manual that's very useful for the beginner and a well-designed reference card. After one reading, however, the manual is not of very much help in running the program. A new manual is being written and may be available soon. In addition, several books are in preparation which will aid the VisiCalc owner in using the program.

Program Constraints

The primary constraint of the VisiCalc program is the programmable memory available to the user. In the Apple II, for example, a 48 K-byte machine will have about 25 K bytes available to the user for modeling. This may sound like a lot, but in fact model files require a lot of room. To compound this problem there is no easy way to

move information between models (for example, in a business consolidation), so that using the same basic information in different models can be a big chore.

The only other limiting factor is the fact that the VisiCalc disk cannot be copied or backed up. The obvious reason for this to avoid software piracy, but it could prove to be a problem if someone decided that 5¼ inches was the perfect size for a coaster. There is a dealer program for instant replacement, however.

Data Interchange Format

Software Arts Inc, the creator of VisiCalc, has developed a common language for data (which it uses in VisiCalc) called the DIF (Data Interchange Format). The basic goal of the DIF is to allow the interchange of data between many different kinds of programs (such as data bases, graphing programs, report generators etc). The type of data which is addressed by the DIF is data which is stored in tabular form — columns and rows. By setting up a standard for such data handling it becomes easy to manipulate the data through program control.

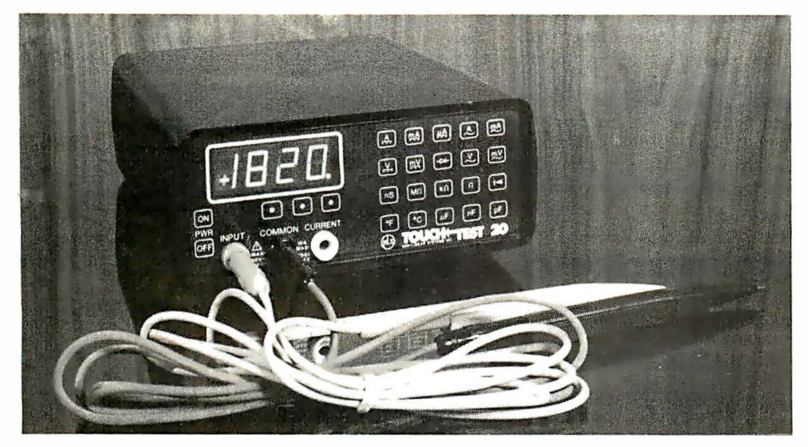
Programmers and others who are interested in learning more about the DIF or would like to purchase the *Programmer's Guide to Data Interchange Format* ($1.50) should write to The DIF Clearinghouse, POB 70, MIT Branch, Cambridge MA 02139.

Conclusions

- VisiCalc is an extremely well-designed software package that can be used by anyone with or without a programming background. There is no programming language involved in the use of VisiCalc.
- The instant interaction between the user and the screen facilitates the understanding of the manipulation of the variables in the matrix.
- The ability to interchange data with other programs helps make VisiCalc an integral part of any business systems package.
- VisiCalc is the first program available on a microcomputer that has been responsible for sales of entire systems. ■

-Technological Breakthrough-

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There's much more to tell about this incredible little meter that takes the place of at least 3 separate test instruments, but we're sure that the Touch Test 20 will end up very near the top of your equipment list.

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For three decades, the inventors of the Touch Test 20, Non-Linear Systems, have made a science of staying ahead through innovation in test equipment. In 1952, NLS propelled electronic testing into the space age by introducing the world's first digital voltmeter, and they have remained committed to first rate value and performance through sophisticated, yet simplified electronic test tools. Their battery powered portable oscilloscopes have "lightened the load" of both field and laboratory engineers all over the world, and NLS digital panel meters have also become a world-wide standard.

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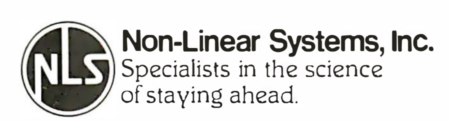
3 lb 8 oz TEST LAB

We think the Touch Test 20 is miniaturization at its best, because no compromises in accuracy and versatility were made in the process of squeezing a trunk full of test equipment into a rechargeable battery powered portable test lab.

It will measure AC voltage, AC current, resistance, capacitance, conductance, temperature, DC voltage, DC current, continuity, and test diodes - 20 key test functions, 10 electrical parameters and 44 ranges. Now, you can take one lab to the field instead of a cumbersome collection of individual testers. And in the lab, the Touch Test 20 will go a long way toward cleaning up the cluttered array of equipment found on most test or troubleshooting benches.

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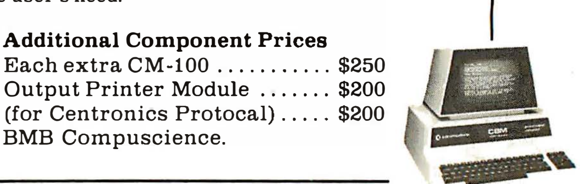
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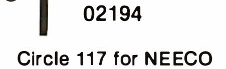
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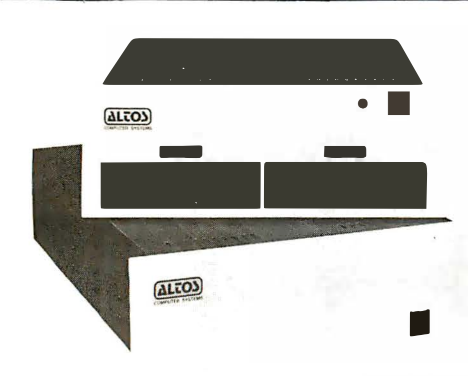


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The MicroAngelo Video Display

Mark Dahmke
1515 Superior St
Lincoln NE 68521

Introduction

The MicroAngelo high-resolution raster graphics display stands well above other S-100 graphics displays in its price and performance range. Since the MicroAngelo is actually a single-board microcomputer, a great number of functions that previously had to be performed by the host computer are now done in *firmware* on the graphics board. Rather than using the memory-address space of the host as a graphics display buffer (32 K bytes in this case), the host communicates with the MicroAngelo through two parallel ports with simple yet powerful commands. The MicroAngelo decodes these commands and automatically performs the desired functions independently of the host processor. With this parallel-processing capability, system response time is greatly enhanced.

Hardware Overview

The MicroAngelo consists of a Z80A microprocessor with 32 K bytes of on-board programmable memory and 4 K bytes (expandable to 8 K bytes) of PROM (programmable read-only memory) firmware. The board contains all hardware necessary to generate a 512 by 480 dot black-and-white display for a television monitor (10 MHz bandwidth or greater). The board communicates with the host through two parallel ports which may be addressed to any of eight blocks of ports from hexadecimal 00 to F0. The video monitor may be connected via composite video (RS-170 standard) or direct-drive transistor-transistor-logic-level video, horizontal and vertical synchronization.

The MicroAngelo has four possible interrupt sources: data from host, data to host, light pen, and 60 Hz timer. Whenever a data byte is sent by the host or the host reads a data byte sent to it, an interrupt will occur in the MicroAngelo. An interrupt will occur when the light pen is fired and also when the timer produces a pulse. Of these four possible interrupts only the data from host and light pen sources is usually enabled.

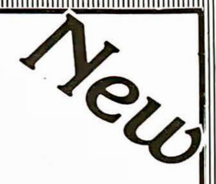
At a Glance

Hardware:	*MicroAngelo high-resolution graphics display.*
Use:	*High-resolution raster-scan graphics display which may be used to draw character or graphics images on a standard television monitor.*
Manufacturer:	*Scion Corporation 8455-D Tyco Rd Vienna VA 22180 (703) 827-0888*
Price:	*The MicroAngelo graphics board and firmware (the S-100 board only) is $1095. Also available is the Graphics Subsystem which includes the MicroAngelo S-100 board, a graphics keyboard (IBM Selectric-style keyboard with some special function keys) and a high-resolution 15-inch monitor. Cost: $2495. A light pen is optional.*
Features:	*The MicroAngelo S-100 board generates a 512 by 480 dot black-and-white raster display. Communication between the MicroAngelo and the host computer is facilitated by two parallel ports. The MicroAngelo also has a dumb terminal emulation mode.*
Firmware:	*PROM (programmable read-only memory) firmware is provided on-board the MicroAngelo. High-level commands may be sent via parallel ports. Such functions as "turn on dot" or "draw vector" are implemented by single commands. The on-board Z80 intercepts these commands and performs the desired functions.*
Hardware required:	*Any S-100 mainframe computer or any computer which has an S-100 bus adapter. Although the MicroAngelo uses a Z80 microprocessor, the host processor need not be 8080/Z80 compatible.*
Documentation:	*An eighty-page user's manual is supplied.*
Audience:	*Anyone requiring high-resolution intelligent graphics on a small system.*

Circle 121 on inquiry card. →

New

S-100 A/D & TIMER



Tecmar's new A/D and Timer Board is designed to meet sophisticated data acquisition needs. The board can accommodate various A/D modules providing options such as 12, 14, 16 bit accuracy; 100 MHz throughput; variable ranges and gains. It contains a powerful timer circuit (AMD 9513) which can start A/D conversion and can also be used independently for time of day, event counting, frequency shift keying and many other applications.

TM-AD200 FEATURES

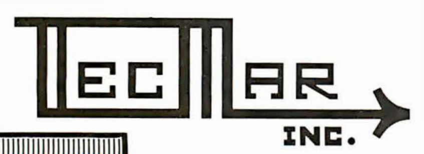
- Complies with IEEE S-100 specifications
- Transfers data in 8 or 16 bit words
- 30 KHz throughput standard
- 12 bit accuracy standard
- Jumper-selectable for 16 single-ended or 8 true differential channels
- External trigger of A/D
- Provision for synchronizing A/Ds
- Data overrun detection
- Data is latched providing pipelining for higher throughput
- Input ranges: ±10V, ±5V, 0 to +10V, 0 to +5V
- Output formats: Two's complement, binary, offset binary
- Auto channel incrementing
- I/O or memory mapped
- Utilizes vectored interrupt or status test of A/D
- Provision for expansion to 256 channels

TIMER FEATURES

- 5 independent 16 bit counters (cascadable)
- 15 lines available for external use
- Time of day
- Event counter
- Alarm comparators on 2 counters
- One shot or continuous frequency outputs
- Complex duty cycle and frequency shift keying outputs
- Programmable gating and count source selection
- Utilizes vectored interrupt

TM-AD200 OPTIONS

- Programmable gain up to 500
- 14 bit accuracy
- 16 bit accuracy
- Screw terminal and signal conditioning panel with optional thermocouple cold junction compensation
- 100 KHz throughput with 12 bit accuracy
- Low level, wide range (10mV to 10V FSR) permitting low level sensors such as thermocouples, pressure sensors and strain gauges to be directly connected to the module input



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(216) 382-7599
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If your data acquisition needs are simple, the original Tecmar S-100 A/D Board will meet your needs.

TM-AD100 FEATURES — $495

- Complies with IEEE S-100 specifications
- 16 single-ended or 8 true differential channels
- 12 bit accuracy
- 25 KHz throughput
- I/O or memory mapped
- Input ranges: ±10V, ±5V, 0 to +10V, 0 to +5V
- Minimal software required.

For digital to analog conversion, Tecmar's D/A Board provides four independent 12 bit high speed D/A channels.

TM-DA100 FEATURES — $395

- Complies with IEEE S-100 specifications
- 4 independent digital to analog converters
- 12 bit accuracy
- 3 μsec settling time
- I/O or memory mapped
- Output ranges: ±2.5V, ±5V, ±10V, 0 to +5V, 0 to +10V

S-100 BOARDS

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- 8 Ch. Differential
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D/A

- 12 Bit
- High Speed
- 4 Channel
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- Digitizes and Displays in 1/60 sec, flicker-free
- 16 Gray Levels
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- Maximum Resolution: 512 pixels/line x 240 lines
- Minimal software requirements

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Data Acquisition Systems and Video Microcomputer Systems Available

A connector is provided for the light pen interface. Several commercially available light pens will work with the MicroAngelo.

Jumper Options

Several on-board jumpers are provided for special applications. For example, it is possible to increase the clock speed of the Z80A microprocessor (and hence the speed of the board) from 4 MHz to 5 MHz, assuming that all the components are capable of operating at that speed. Interrupts (as previously discussed) may be enabled or disabled. The number of visible scan lines may be changed from the default 480 to 448 lines. If this option is chosen, the user is responsible for display management. The PROM sockets may be jumped to either the default 1 K byte per PROM or 2 K bytes per PROM.

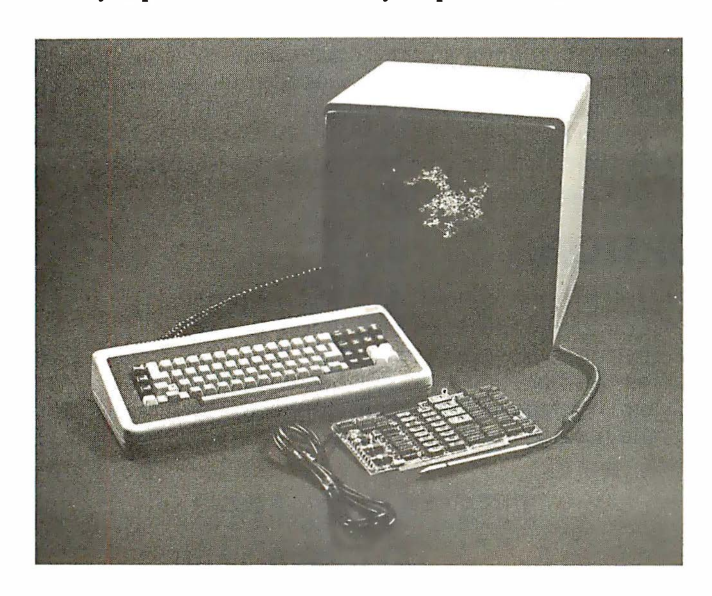


Photo 1: *The MicroAngelo Graphics Subsystem. Included in the subsystem are the MicroAngelo S-100 board, the 15-inch high-resolution black-and-white monitor, and a special keyboard that has an IBM Selectric-style layout plus some special function keys on the far left and right. The light pen is optional.*

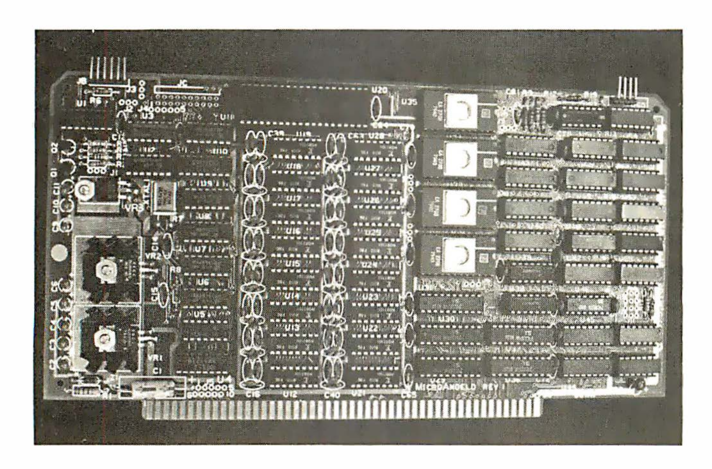


Photo 2: *A close-up of the MicroAngelo S-100 board. The board has a Z80A microprocessor, 32 K bytes of memory, and four 2708 PROMS (expandable to 8 K bytes 2716 PROMs). The board is actually a stand-alone 32 K computer. The video display generates 512 by 480 dots. In the ALPHA mode, up to 85 by 40 characters may be displayed on the screen.*

Adapting-MicroAngelo to Non-S-100 Systems

Since the MicroAngelo uses a simple parallel-port interface to the host system, it may be attached to almost any host system. Data is transferred via the eight parallel input and eight output lines of the S-100 bus connector. Power is supplied through pin 1 (+8 V), pin 2 (+18 V), pin 52 (−18 V), and pin 50 (ground). Address bus lines A7, A6, A5, A4 and pDBIN may be tied permanently high (+5 V); A1 and p$\overline{\text{WR}}$ are tied low (ground). A0 is connected to the host to select whether port 0 or 1 is addressed. (MicroAngelo uses two ports.) sINP and sOUT are connected to the host as input-and-output-control command lines. Using this twelve-line interface, the MicroAngelo becomes a stand-alone graphics display device. If interrupts are required, they may be easily added to the above set of signals.

Firmware

The MicroAngelo firmware is what makes the board so powerful. It takes all the work out of designing software and applications programs for the MicroAngelo. The Screenware Pak I is a well-integrated firmware package that allows the board to be used as a terminal emulator, a graphics display, or both.

If a byte is sent to the MicroAngelo (via the parallel port), it is interpreted by the firmware in one of two ways. If bit 7 (the most significant bit) is turned on, the byte is seen as a command. If it is off, the firmware treats it as an ASCII character and passes it to the terminal or ALPHA mode program.

In the text mode, the board will display forty lines with eighty-five characters per line. Text and graphics may be mixed on the screen. In the dumb terminal mode, the firmware will respond to the following control codes: backspace, horizontal tab, line feed, form feed, carriage return, escape, and delete.

Several features are available in the terminal mode. It is possible to display black-on-white or white-on-black characters, for example. Underlining may be turned on and off, and character overstriking may be allowed or disallowed. Two fonts are available, the standard character set or a user-defined font. The winking cursor may be displayed or inhibited, and the scroll mode may be changed. Scrolling may be done on a line-by-line basis, or, to improve response time, block scrolling may be done. Cursor addressing is available — rows run from 0 to 39, columns from 0 to 84. It is also possible to query the firmware to obtain the current cursor location.

Graphics-Mode Commands

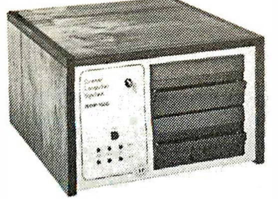
The display may be manipulated in many ways in the graphics mode. First, the graphics cursor may be set to a value, read or queried, or set to the contents of the alpha cursor and vice versa. The format for most graphics-mode commands is:

<Command> <xh> <xl> <yh> <yl>

where *xh* and *xl* are the high and low bytes of the X coordinate and *yh*, *yl* are the high and low bytes of the Y coordinate respectively (in hexadecimal). The coordinates (384,256) would be sent as:

<Command> <01> <80> <01> <00>

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- Sixty-four kilobytes of addressable RAM, the maximum for 8 BIT systems, is not adequate for many business or scientific applications.
- It is not worth buying 8 BIT systems or boards now if you can get the same software with 16 BIT systems at about the same price.
- The new 16 BIT microprocessors have power comparable to minicomputers but do not require the same overhead in terms of downtime, maintenance, or initial investment. They are more versatile in many applications such as real time applications.

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- A Z-8000 Board that can plug into your existing S-100 Bus System (see below for description)
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SYSTEMS



QDP-8100 WITH 2 MEGABYTES STORAGE STANDARD (OPTIONAL 4 MEGABYTES)

- Z-8000 series 16 BIT CPU S-100 Board - see above

SOFTWARE (Provided with system)
- CP/M 2.2[1] operating system
- Basic
- Z-80/8080 Emulator
- Monitor, Debugger, Disassembler software
- Optional software: Pascal
- UNIX[2] operating system coming

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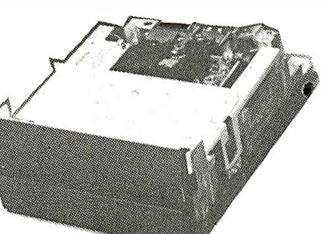
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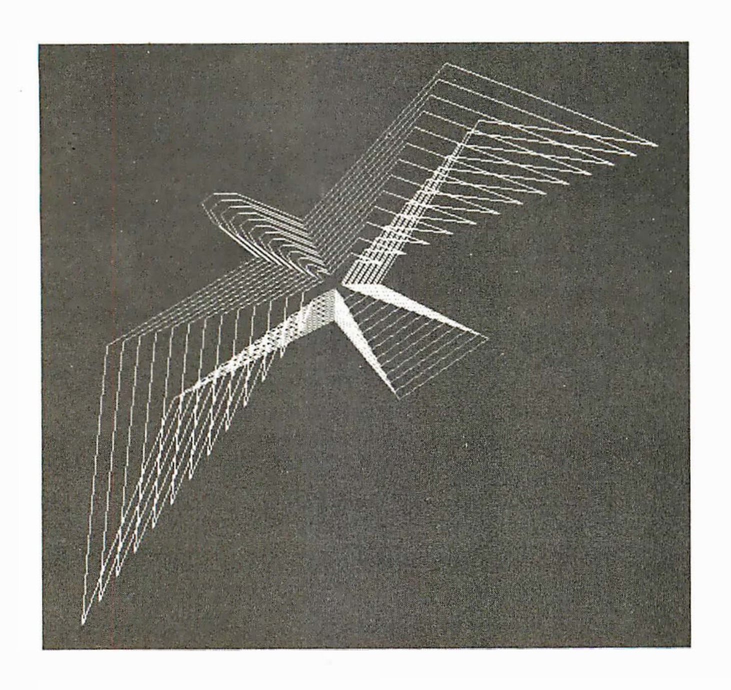


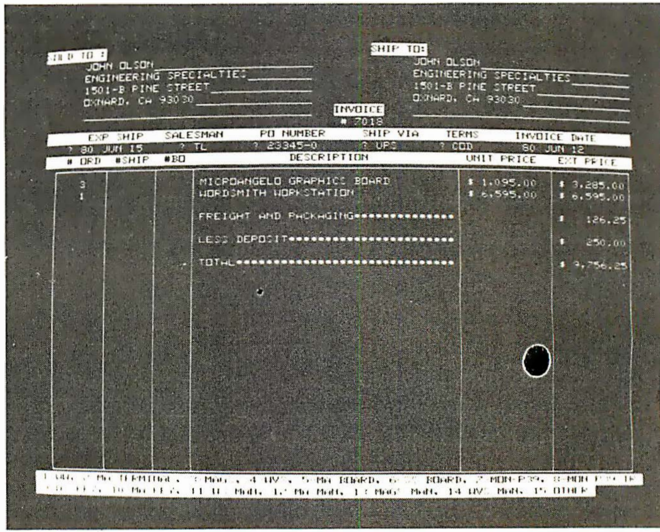
QUASAR DATA PRODUCTS

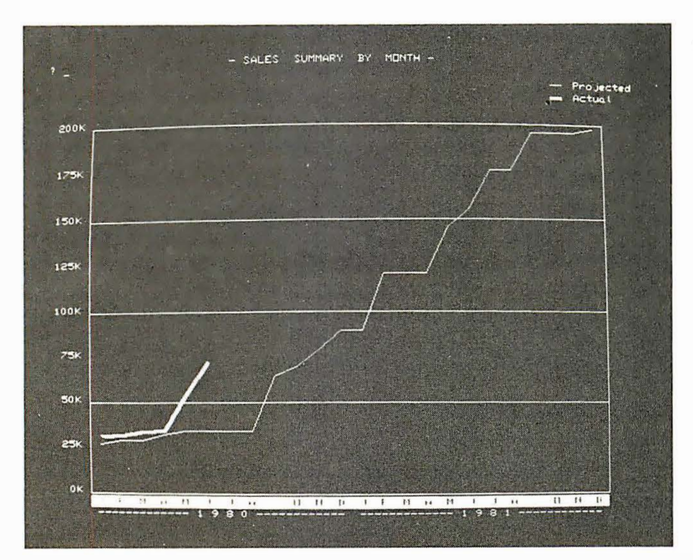
10330 Brecksville Rd., Brecksville, OH 44141 (216) 526-0838 or 526-0839

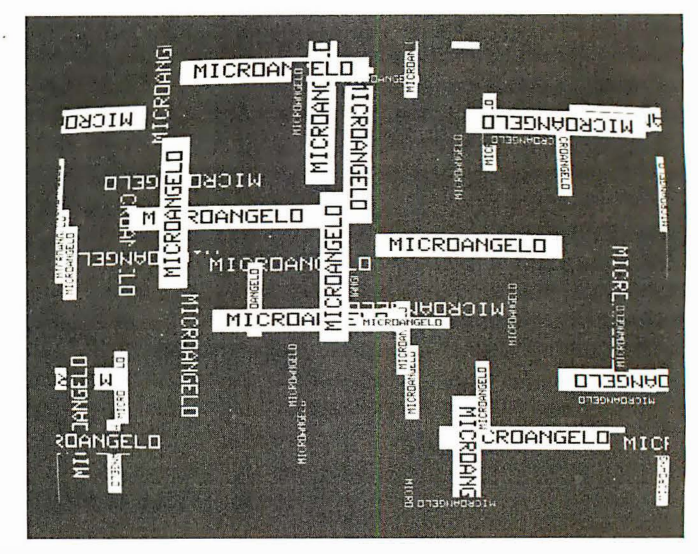


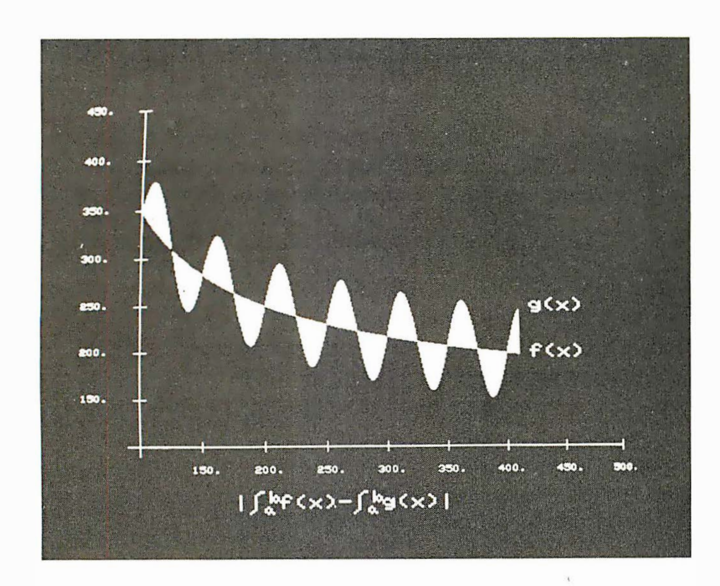
Circle 122 on inquiry card.











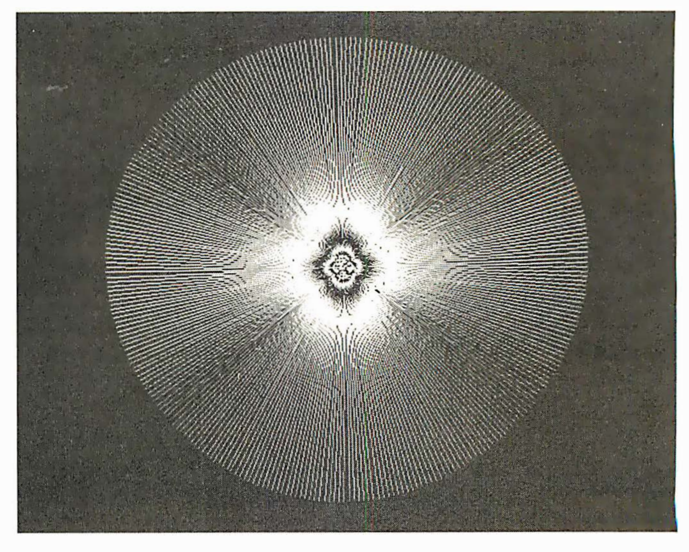
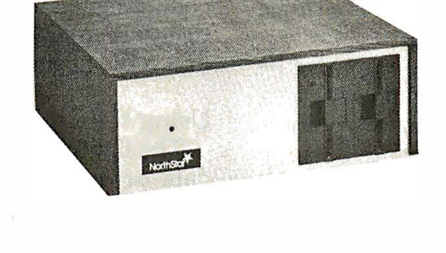


Photo 3a, 3b, 3c, 3d, 3e, 3f: *Sample displays produced with the MicroAngelo graphics board. Vectors may be drawn with single high-level commands.*

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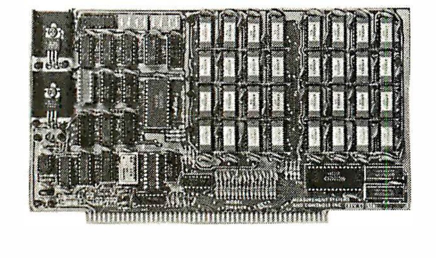
NORTHSTAR

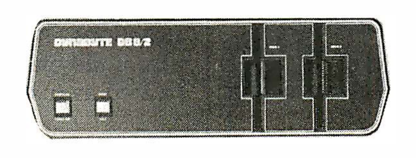
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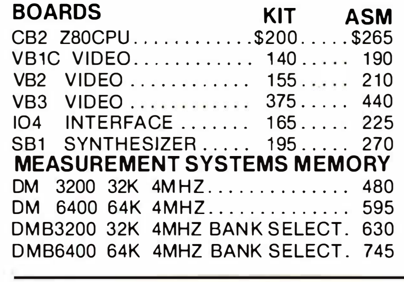
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Replacing <Command> with <84> would cause the firmware to set the graphics cursor to (384,256) on the screen. Some commands have no operands such as "clear screen". It is possible, with one command, to toggle the screen figure/ground. This means that every dot on the screen will be complemented (ie: reversed). If a dot is *on* (white), it will be turned *off* (black) and vice versa.

Individual dots may be turned on, off, complemented or queried. The form of this group of commands is also:

<Command> <xh> <xl> <yh> <yl>

In the case of the query command, the response is a single byte from the firmware with a value of 1 or 0.

A vector, the next level of sophistication, may also be turned on, off or complemented. The endpoint of the vector is specified in the command, and the starting point is assumed to be the current value of the graphics cursor.

It is also possible to work with *regions* of the display. If we wish to turn on all dots in a box with corners (X1,Y1), (X2,Y1), (X1,Y2), (X2,Y2) the command:

<95> <x1h> <x1l> <y1h> <y1l>
<x2h> <x2l> <y2h> <y2l>

would be sent. Regions may also be turned off or complemented.

Characters may be *plotted* depending on the graphics cursor and the mode selected for graphics characters. Options available include:

- normal-size or double-size characters
- black-on-white or white-on-black
- direction and orientation

Alternate characters may be defined. When the ALPHA mode alternate-character-set option is employed, sending an ASCII character to the firmware will display the alternate character instead of the standard font character. To define the character, the following sequence of bytes must be sent:

<9A> < asc> <s11> <s10>
<s9> ... <s1> <s0>

where 9A is the command, "asc" is the ASCII character code assigned to the character, and s11, s10, ... s0 are the twelve scan lines (6 bits wide) that make up the character in a 6 by 12 dot array.

Using the Light Pen

The light pen provides a convenient means of entering data or drawing on the screen without having to enter numeric coordinates. The coordinates of the pen may be read directly, along with a flag indicating whether or not the pen has been fired since it was last queried. Cross hairs may be displayed at any point on the screen when using the light pen. Another set of commands allows the cross hairs to be displayed, moved, and queried without regard to the light pen.

Memory Uploading/Downloading

Several commands are provided for dumping and loading the screen, thus allowing the user to save images on disk and restore them for later viewing or editing. Memory blocks may be examined or deposited allowing quick loading of alternate character fonts or user-written code. The firmware allows the user to deposit Z80 instructions in unused blocks of on-board memory. The user code may be defined as an op code and thereafter treated as just another firmware command.

Concerning Gray Levels and Color

The one drawback of the MicroAngelo is that it does not have gray levels — meaning the ability to have levels in between black and white or on and off. However, I was informed by Scion that another product, as yet unnamed, is available. This is another S-100 board which mixes the output of three or more MicroAngelo boards to produce *color, gray levels, or both*; four colors can be obtained with as few as two boards.This scheme does require more than one MicroAngelo board, but compared to other graphics displays with 512 by 480 resolution, this approach is still cost-effective. The board does offer interesting possibilities: 256 gray levels, the 256 possible hues or colors, and the winking of dots on an individual dot basis. Also, it is possible to use the winking effect to alternate between two colors.

Conclusions

The MicroAngelo video display system provides quality high-resolution graphics capabilities to S-100 bus (or similar) microcomputer systems, with an exceptional price-to-performance ratio.

On-board firmware provides a simple but powerful set of commands that makes system integration easy.

Although the board is designed to run on the S-100 bus, it can be easily adapted to almost any other bus or input/ouput port organization and does not require an 8080 or Z80 host computer. ■

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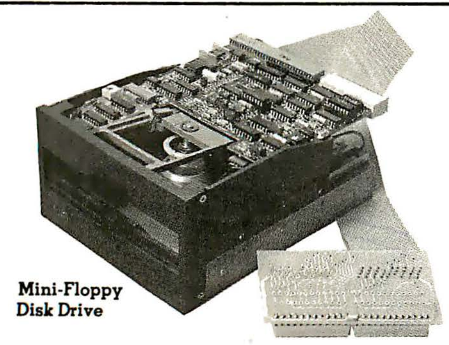
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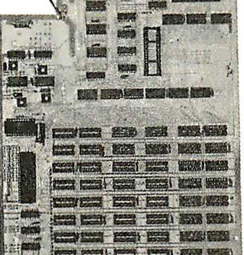


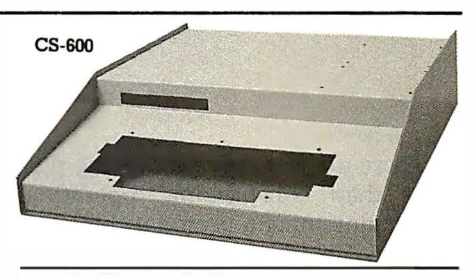
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610 Board


CS-600

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Inevitably, system failures will occur and can usually be remedied by personal knowledge and help from numerous books and articles on computer-circuit theory. But one frequently neglected area is the operational theory of the most used human-to-computer interface: the monochrome video monitor.

The video monitor is a basic part of most personal computer systems. The theory described here applies to converted television receivers and professional monitors. The two differ mostly in the video amplifier's frequency response and the cathode-ray-tube phosphor color: a professional monitor has a greater frequency response and a green phosphor. Additionally, the professional monitor has no tuner, intermediate frequency amplifier, video detector, sound or AGC (automatic gain control) sections, which are necessary in the broadcast receiver. The latter must have these sections rendered inoperable or selectively switched out when used as a monitor. Our discussion will assume a professional monitor with direct video entry.

The Picture Tube

The fundamental part of the video monitor is the CRT (cathode-ray tube). Various circuits are used to *deflect* and *modulate* the beam.

Figure 1 shows the elements found in the modern picture-tube electron-gun assembly. 6.3 V applied to the heater causes electrons to be emitted or "boiled off" from the cathode surface. The electrons are pulled toward the phosphorus screen by the high positive potential existing at the accelerating anode surrounding the bell of the picture tube. Typically,

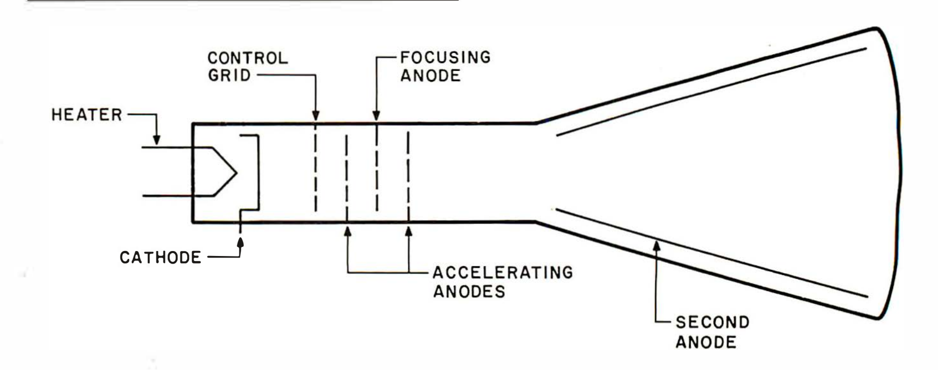


Figure 1: *Internal structure of a cathode-ray tube. The electron beam is emitted by the cathode when it is heated. Electrons are attracted to the screen by a high voltage (12 kV to 20 kV) on the second anode.*

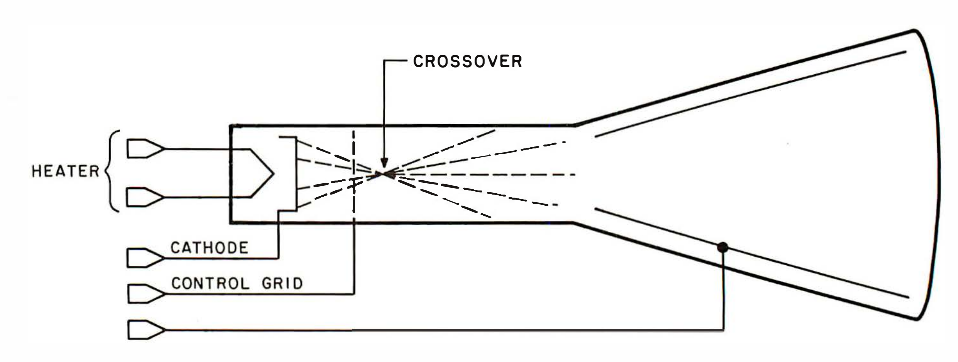


Figure 2: *The crossover effect. Two accelerating anodes, in conjunction with the focusing anode, are used to give a sharp beam and a well-defined screen image. Without the focusing arrangement, the electron beam diverges and splatters.*

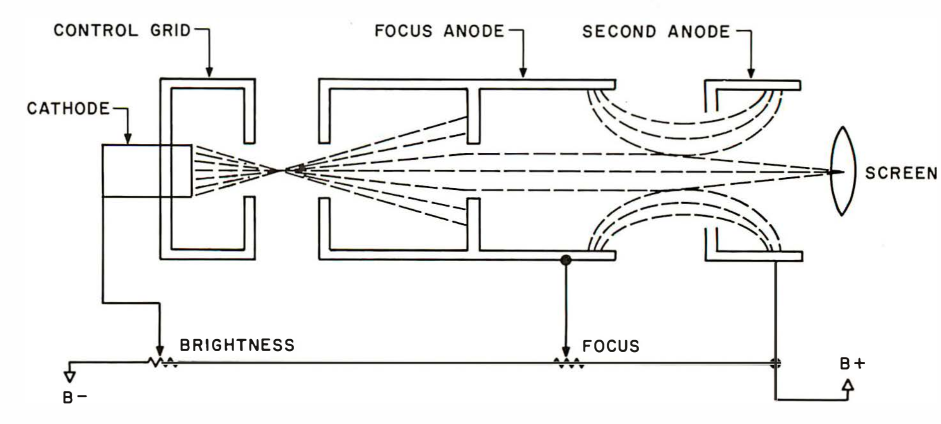


Figure 3: *Focusing the beam. By applying the proper potentials to the anodes and control grids, the electron beam can be "squeezed" to a pinpoint, for displaying the image on the screen.*

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voltages of 12 kV to 20 kV are fed to this anode from the monitor's high-voltage section.

The emitted electrons pass through various control grids and arrive at the screen in the form of a luminescent dot. The brilliance of the dot is controlled by adjusting the potential at the control grid. A voltage more negative than the cathode surface decreases the beam brilliance, while a more positive voltage increases the beam brilliance. Varying the control-grid voltage modulates the beam and produces the shades of black and white that form the picture elements on the monitor screen.

The two accelerating anodes, in conjunction with the focusing anode, are used to give a sharp, well-defined screen image. Without these anodes, the electron beam, after passing through the control grid, would encounter *crossover* and become broad and splattered, as shown in figure 2.

By applying the proper potentials to the accelerating anodes and the focus anode, the beam is squeezed and formed into a well-defined pinpoint suitable for displaying the images on the screen. This result is shown in figure 3.

Deflection Circuits and Rastering

The processes described so far would result in a black screen with a single bright dot in the center of the picture tube. The first step in obtaining a display on the screen is to pull the electron beam from side to side; this illuminates a line on the screen. The beam can be moved from top to bottom, in order to illuminate a whole screen of lines. If this is done rapidly enough, this will produce illumination over the entire area of the picture tube. This process is called *rastering*, and the dimly illuminated screen with no data information present is called the raster.

The *deflection yoke* consists of electromagnetic coils arranged in a vertical and horizontal configuration and is fitted around the picture tube neck; it is the primary device used for deflecting the electron beam. To move the beam from the top to the bottom of the screen (vertically), a rapidly rising (and more rapidly falling) sawtooth-current waveform is passed through the vertical windings of the yoke. Figure 4 shows a sawtooth waveform produced by a typical vertical circuit and the resultant vertical sweep of the beam.

As the current rises (Time A), the buildup of magnetic flux causes the beam to be swept from the top to the bottom of the screen. When the sawtooth reaches maximum value, it rapidly falls to 0 (Time B), causing the beam to be *retraced* from the bottom back to the top of the screen, where the process begins again. During the beam sweep from top to bottom, the trace is visible, but during the retrace the beam is cut off by the *retrace blanking circuitry* to avoid undesirable retrace lines from showing. Vertical sweep of the beam normally occurs 60 times per second.

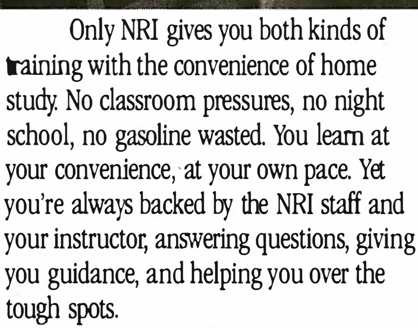
The sawtooth wave is produced in an oscillator and amplifier section of the television monitor and is fed to the vertical windings of the deflection yoke 60 times per second. Vertical beam deflection, if used alone, would result in a bright vertical line in the center of the darkened screen. To complete the rastering process, the beam must also be deflected from left to right, and this is accomplished by the horizontal circuitry.

The horizontal windings in the deflection yoke are also fed with a sawtooth current originating in the horizontal oscillator and output circuitry. The frequency of this sawtooth is 15,750 Hz. The rising sawtooth current is passed through the horizontal windings in the yoke, causing the beam to be deflected from the left to the right side of the picture. The beam is then cut off by the *horizontal blanking circuitry*, and the rapidly falling sawtooth current sweeps the beam back to the left side of the screen to repeat the process. Figure 5 illustrates a typical horizontal oscillator and deflection circuit and the resultant screen trace.

The horizontal sawtooth voltage is produced by the horizontal oscillator and output section. The sawtooth is coupled into a horizontal output transformer before being fed to the deflection yoke windings. The main purpose of this transformer is to produce the high voltage necessary for the accelerating anode at the picture tube. The rapidly falling sawtooth voltage present during beam retrace is fed to the horizontal output transformer which steps it up to a

Text continued on page 212

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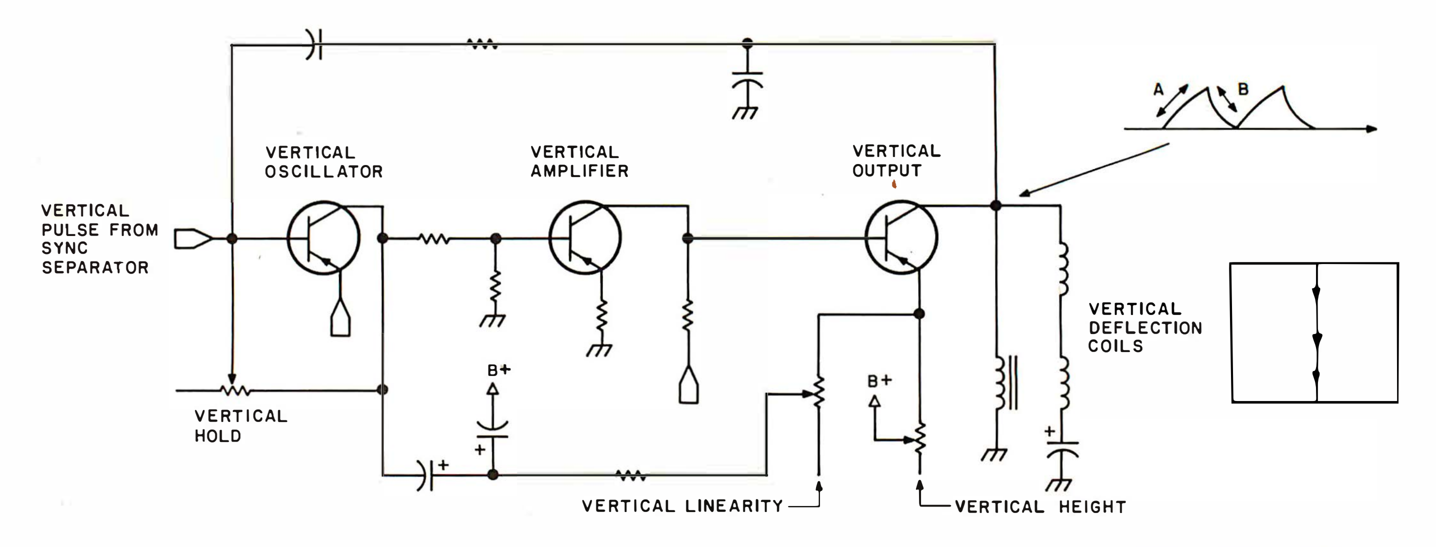


Figure 4: *Typical vertical oscillator/amplifier section. The circuitry shown creates a sawtooth waveform to drive the vertical deflection coils. This enables the electron beam to move from the top of the screen to the bottom 60 times per second.*

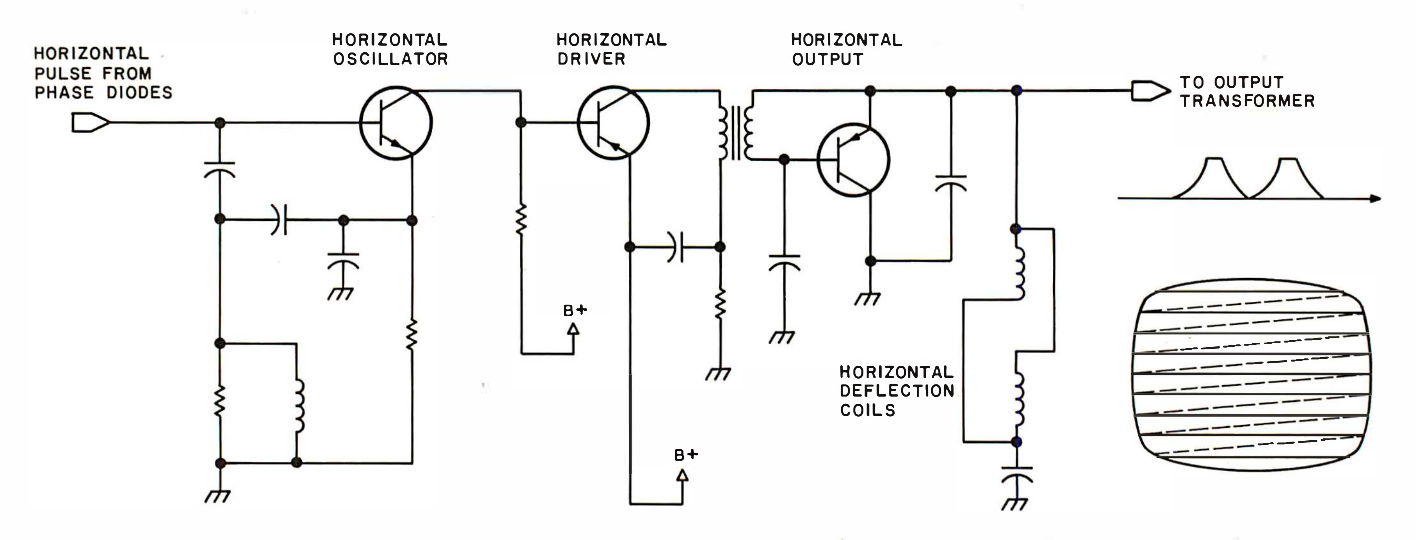
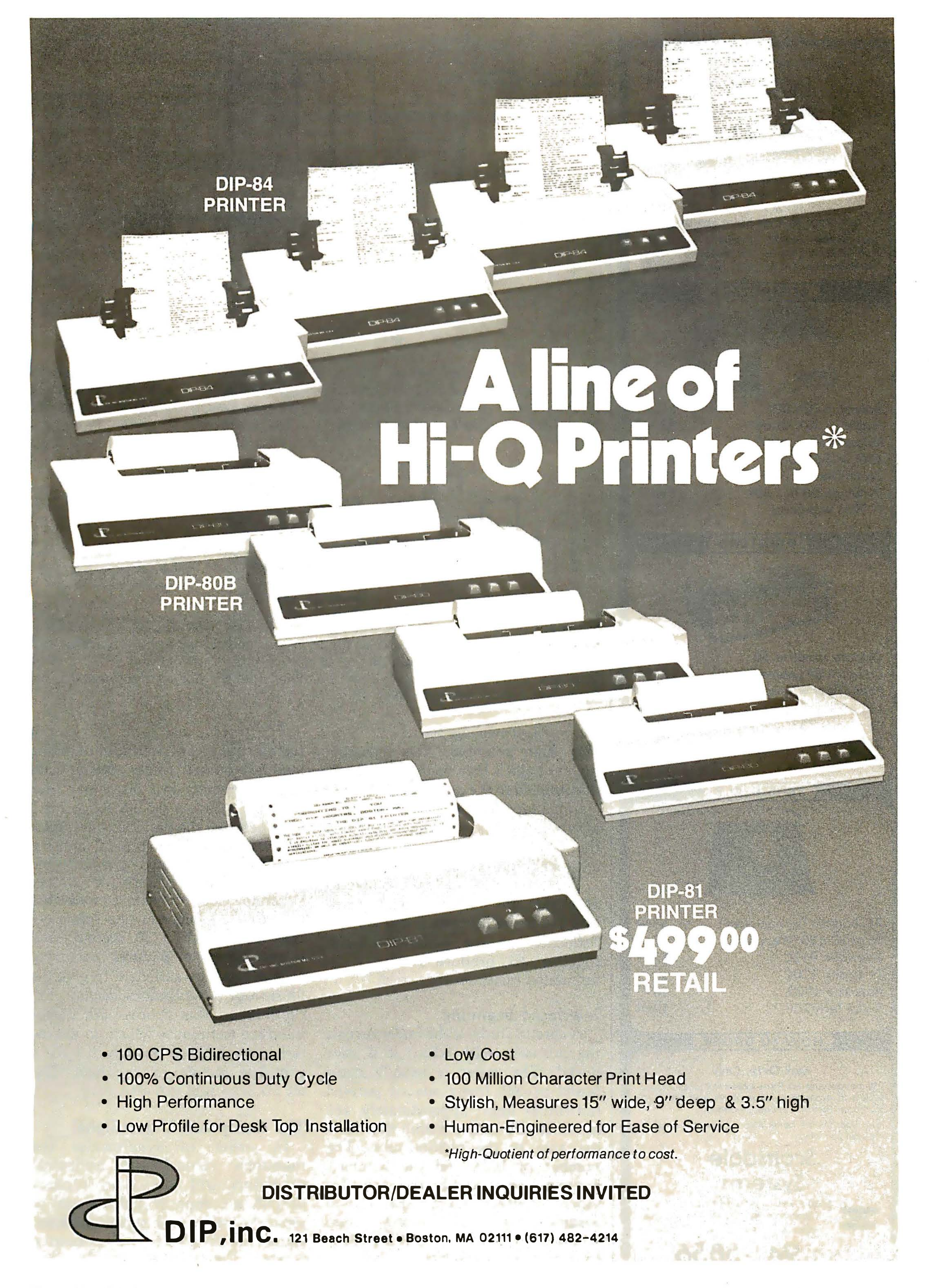


Figure 5: *Typical horizontal oscillator and output yoke. The horizontal deflection coils are driven in a manner similar to the vertical deflection coils, but at a much higher rate of 15,750 Hz.*



Circle 130 on inquiry card.

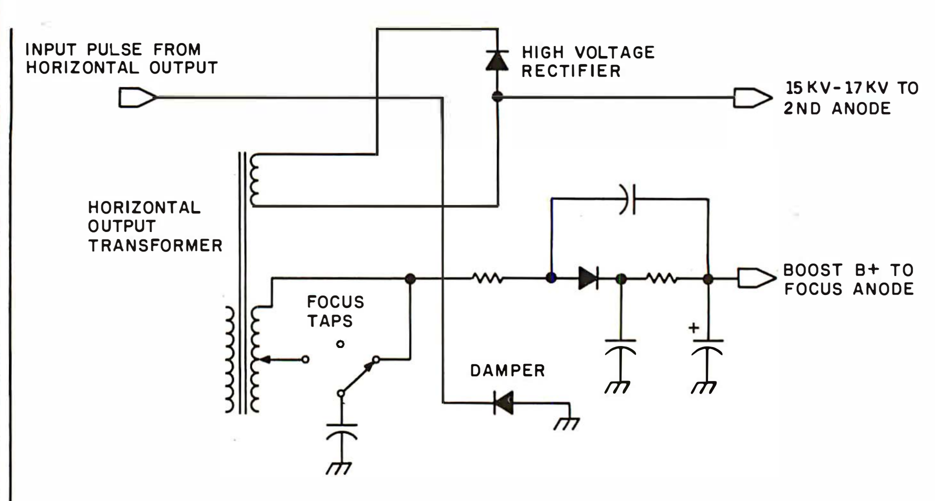


Figure 6: *Typical high-voltage circuit. High-frequency AC from the horizontal-deflection circuitry is also used to produce the high voltage supplied to the focusing and second anodes. After passing through a step-up transformer, the AC is rectified and filtered for use in various other circuits.*

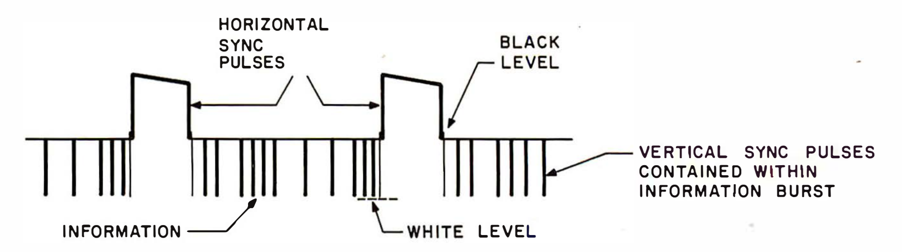


Figure 7: *Composite video signal. The signal sent to most video displays contains large pulses used to keep the horizontal oscillator in time with the picture information. The picture information is essentially an on/off control of the electron beam. In most video monitors, a low pulse turns the beam on, illuminating a dot on the screen; an intermediate voltage turns the beam off.*

Text continued from page 208:
very high potential. This pulsating high voltage is then rectified, filtered, and applied to the picture tube anode. Various taps on the transformer give alternate circuit voltages, including the focus voltage. Figure 6 illustrates a typical high-voltage circuit.

The production of high voltage to accelerate the electron beam combined with the horizontal and vertical deflection of the beam all work together to produce a dimly illuminated raster on the screen.

Interlaced Scanning

A careful study of the raster reveals the precision with which it is produced. The raster is usually composed of 525 finely spaced parallel horizontal lines, approximately 480 of which are visible within the viewing area of the picture tube. The number of lines and the scanning method used depend on the particular video interface used, and I will assume a high-quality monitor used with a video system outputting sixty-four or more characters per line.

The vertical oscillator and output section utilize an interlaced scanning method which traces 262.5 lines across the screen in 1/60 second, then returns to trace a second set of 262.5 lines *between* the previous lines. Each set of lines is called a field, and the two fields combined produce one complete data picture or frame. When the electron beam is modulated to produce a picture, one frame occurs once each 1/30 second, and thirty complete pictures occurring each second are sufficient to give the illusion of a continuous display. Exceptions to this process are video-interface techniques which do not interlace their fields but which trace a complete picture in one field. The 60 Hz scan rate can also vary.

The Composite Video Signal

In order to synchronize the monitor's vertical and horizontal oscillators with the video-interface output, a composite video signal or separate video and synchronization signals are coupled to their respective stages. The purpose of the syn-



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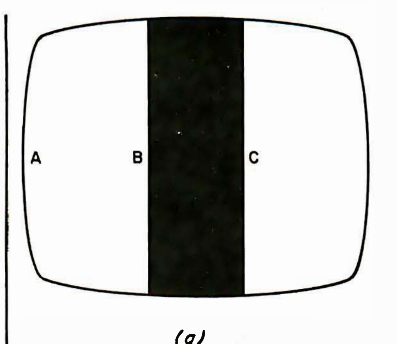
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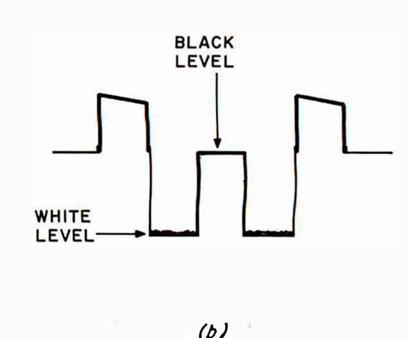


Figure 8: *Sample video display and corresponding composite video signal. The low portion of the composite signal (b) turns on the electron beam to illuminate the screen (a). When the intermediate voltage of the black portion is encountered, the beam is turned off. As the composite signal returns to the low white level, the screen is illuminated again.*

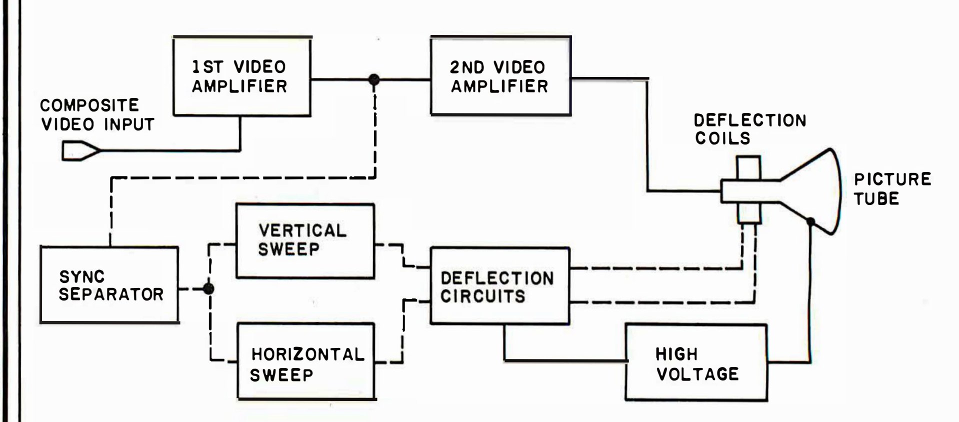


Figure 9: *Block diagram of the signal path in a typical monitor. The solid lines represent actual video information, while the dashed lines indicate the path of synchronization signals.*

chronization signals is to time the vertical and horizontal oscillator stages to the video information fed to the picture tube. Figure 7 is a sketch of the most widely implemented composite video signal.

This signal contains both the horizontal and vertical synchronization pulses (called *sync* pulses) and is applied to the *sync separator* where the horizontal and vertical pulses are separated, amplified, and sent to their respective oscillators to synchronize their respective traces. Included in the vertical sync pulses (assuming interlaced scanning is used) are equalization pulses whose function is to assure that the second field of lines is interlaced with the first.

Electron-Beam Modulation

The last link in the chain to create an image is to modulate the electron beam, turning it on and off to display white dots on the dim raster; this forms the dot matrices arranged as alphanumeric characters. The information contained in the composite video signal is actually a series of voltage reference levels which are amplified in the video amplifier and applied to the control grid or cathode of the picture tube to turn the electron beam on or cut it off. The black field in the display is represented by a voltage near the black level just under the horizontal sync pulse. Figure 7 illustrates this. The white dots in the picture are represented by the white level, or minimum voltage. In scanning the display shown in figure 8a, when the beam begins its trace at point A, the voltage level is minimum, or white as in figure 8b. When point B is reached, the voltage level jumps to the black reference level and cuts off the beam at the picture tube. A black screen is evident. At point C, the beam is on again, and white is presented.

Production of a display on a video terminal is more complex, but the beam is modulated in the same way to produce numerous dots of white



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(corresponding to data elements sent from the video interface). Alternate methods employ black data elements on a white field. The frequency response of the video amplifier stages determines how fast the beam can be turned on and off; the faster the response, the more data elements can be displayed on each line with good resolution.

Home Television Receivers

The video amplifier section in a professional monitor differs greatly from that in a television receiver. Television receivers can rarely be modified to produce dots of a rate beyond 5 MHz, while monitors can be purchased with from 12 to 100 MHz response. The converted television receiver must have its tuner, intermediate frequency amplifier and sound section switched out when employing direct video input. The limited frequency response generally allows only up to thirty-two characters per line, but the low cost of such receivers makes them an attractive choice.

After injection and amplification of the composite video signal in a television receiver used for video display, the video is separated from the synchronization pulses, and the latter are sent to the synchronization section. The separated video information is then amplified by the video amplifier, coupled to the picture tube, and used to modulate the electron beam. In systems using separate video and synchronization inputs, the vertical and horizontal pulses are not processed in a synchronization separator, but are fed directly to their respective oscillators. The separate video is directly coupled to the video output stage.

Troubleshooting

When all the circuits described above are working in perfect unison and are synchronized by the composite video signal, a stable display will be produced. A malfunction at any stage in the monitor creates a problem peculiar to that particular section. So, what do you do when the monitor fails?

The first step is to obtain a good, accurate schematic of the circuitry (preferably *before* any problems occur). The manufacturer should supply this. Locating problems can be somewhat simplified by considering a monitor as consisting of the sections shown in the block diagram of figure 9. Using this diagram, we can observe the signal flow lines to generally predict the section where the problem may lie. Some symptoms and their solutions will prove helpful.

- No Video or Raster: Assuming that the power supply is functioning, the absence of raster could mean that the electron beam is not being deflected across the picture tube screen. Perhaps no beam is present, so the logical checkpoint is the high-voltage section to see if the beam accelerating potential is present. Use of a high-voltage probe is necessary here.

  If the high voltage is present at the anode of the picture tube, it is best to measure voltages at the control grid and cathode of the picture tube, assuming that a visual check revealed that the heater was lit. Having cleared the picture tube and proving that a beam can be formed, proceed to check the horizontal-sweep section where

voltages originate which directly or indirectly affect both horizontal and vertical deflections of the beam. The final step would be a check of the deflection system itself.

- No Video — Raster Present: A raster always indicates that vertical and horizontal sweep, deflection, high-voltage and low-voltage sections are working. Assuming a video signal is present, we should investigate all portions of the monitor's video amplifier section, also the picture-tube-control-grid and cathode circuits.
- Raster and Video Present — Vertical Rolling: Assuming the vertical hold control does not stop the vertical roll, this indicates that the vertical oscillator is not in step with the video interface signal. The obvious starting point is the vertical sweep section, particularly the vertical oscillator.
- Raster and Video Present — Horizontal Lines: This problem is very similar to the above vertical problem, except that horizontal lines are the problem. Again, this indicates that the horizontal oscillator is out of step with the video interface circuitry. Investigate the horizontal oscillator to correct this problem.
- Raster, Video Present — Display Rolling and Drifting Sideways: This is both a vertical *and* horizontal problem. Obviously the circuit feeding both horizontal and vertical oscillators is at fault, and this would be the synchronization separator or amplifier. When symptoms or tests indicate one section as the probable point of trouble, proceed to check voltages for direct-current biasing and use an oscilloscope to investigate waveforms.

Troubleshooting is a logical, step-by-step procedure. In repairing your monitor, the screen is the best visual aid you have, and should be utilized to the utmost in preliminary generalizations as to the problem circuit. And troubleshooting a video monitor yourself, whether or not it's homebrew, can give you the satisfaction of knowing your hardware a little bit more. ■

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Digital Storage of Images

Thomas Williams
39A Mill St
Maynard MA 01754

The availability of inexpensive computer memory has brought high-resolution gray-scale and color graphics within the reach of the home computer experimenter. Over the last decade the ability to capture video signals in digital form, manipulate the stored data, and display it has moved from military and research engineers to undergraduates and interested hobbyists.

Quantization

Before examining methods of capturing video signals, let's look at image quantization, which is the process of converting an image into one or more arrays of numbers. The value of each array element represents the measure of light present in the area of a corresponding point in the original image. These array or picture elements are called pixels.

A typical gray-scale image might be quantized into a two-dimensional array of values that range from 0 to 15, representing intensity values from black to white. If the array were 256 by 256 elements or 64 K pixels, each with a 4-bit value, the array would occupy 32 K 8-bit bytes of memory.

Scanning

To perform the quantization, the image is scanned by a transducer capable of converting light into an electronic signal. This signal is sampled periodically, and each sample is converted into a numeric value. Transducer sensitivity, scanning rate, and sampling rate all affect the quality and form of the digital image.

There are basically four methods of scanning images. The first requires the movement of the transducer with respect to the image or scene. This is typically done by drum scanners where an image is spun under a light source and photodiode. (See figure 1.)

> No matter how much effort is spent on improving the system, the results are only as good as the input.

The second method deflects either a light beam or sensor optics in two dimensions to scan the image. This method is often used in a device called a flying-spot scanner; such devices were used during the first decades of television for transferring movies to video form for broadcast.

The third method is the use of a television camera. In a television tube (ie: a vidicon) the image is focused on a target that is scanned with an electron beam. (See figure 2.) It can be thought of as a CRT (cathode-ray tube) working in reverse.

The fourth method, which is still rather expensive, is the photodiode-array camera. It uses an integrated circuit which contains an array of photodiodes and circuitry to help scan the array. Advantages of this camera over vidicons are the stability of its geometry (as vidicons require electron-beam deflection which is never completely repeatable and accurate) and the inherent immunity to shock (as vidicons are vacuum tubes and thus sensitive to abuse).

Video Costs

As with anything electronic, there are uncontrollable costs of precious metals and precision parts, and controllable costs of design and assembly. Hardware hobbyists with good supplies of parts can usually find clever ways of cutting costs. Most of us, though, have limited resources and must buy kits or search for bargains on assembled equipment. Video cameras sometimes show up at flea markets in various states of repair and can provide you with a good video signal at very low cost. Home-video enthusiasts and closed-circuit security systems have also provided a marketplace for inexpensive cameras.

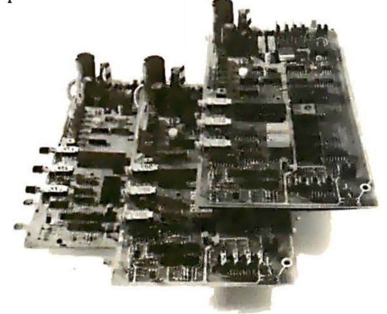
Cameras with sufficient quality for use with digital image-capture systems can be quite expensive. The increased costs usually provide more geometric linearity and a more uniform imaging-target surface. Black-and-white cameras range in price from about $200 to $10,000. At the lower end of the price scale you can expect about 5% error in the linearity of the vertical and horizontal scanning. Usually these errors are not noticeable. Geometric linearity is only important when the image-capture system is used for a precise geometric task, such as measurement of object size.

Target nonuniformity *is* a source of concern. Inexpensive cameras may have differences in video level (for uniform illumination) across the im-

Why is the 88G Printer the new industry leader?

QUALITY

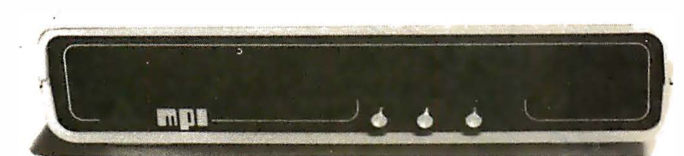
The attractive, durable 88G casework is formed from impact-resistant, flame-retardant Styron. Microprocessor controlled stepper motors provide precision control over print head and paper positioning. Computer quality tractors position paper for readability and are fully adjustable to accommodate varying paper widths.



MICROPROCESSOR CONTROLLED INTERFACE

The microprocessor array provides the intelligence for a dual RS232 serial and a Centronics® type parallel interface. Both inputs are fully buffered to allow the 88G to receive data and print simultaneously. A 1K character buffer is standard with a 2K buffer available as an option.

The short line thruput of the 88G has been increased by incorporation of a *Quick Cancel* feature that fully utilizes the bidirectional/unidirectional printing capabilities. Built-in diagnostic and self-test capabilities allow the user to easily pinpoint system problems and a *Power On* confidence test verifies operational status of the printer each time power is applied.



VERSATILITY

The 88G prints a full upper and lower case 96 character ASCII set with a crisp, clear 7x7 matrix in 80, 96, or 132 column formats. For text processing and correspondence applications, an 11x7, 80 column serif style matrix can be selected by switch or software command. The dual tractor/pressure-feed paper drive system allows the user to choose either pin-feed, roll, or single sheet papers up to 9.5 inches wide.

Complete forms control allows the 88G to be quickly configured for printing single or multiple-ply invoices, purchase orders, checks, or any type of preprinted form. Optional paper roll holders and single sheet feeders can be quickly attached.

The wide use range of the 88G makes it the perfect companion for business systems, data processing, RO teleprinter and terminal printer applications.

GRAPHICS

A high-resolution, dot-addressable graphics option can be added for applications requiring plotting, printing of screen graphics, drawings, illustrations, etc. Single dot print resolution greatly extends the usefulness of the graphics capability. Selection of one of the four horizontal dot densities available customizes the graphic printout, and alphanumerics can easily be included for titling of graphs and illustrations.

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Ribbon difficulties are minimized through use of a continuous loop cartridge with a five million character life. It is easily changed without opening the case, and without any complicated or messy threading operations.



PRICE

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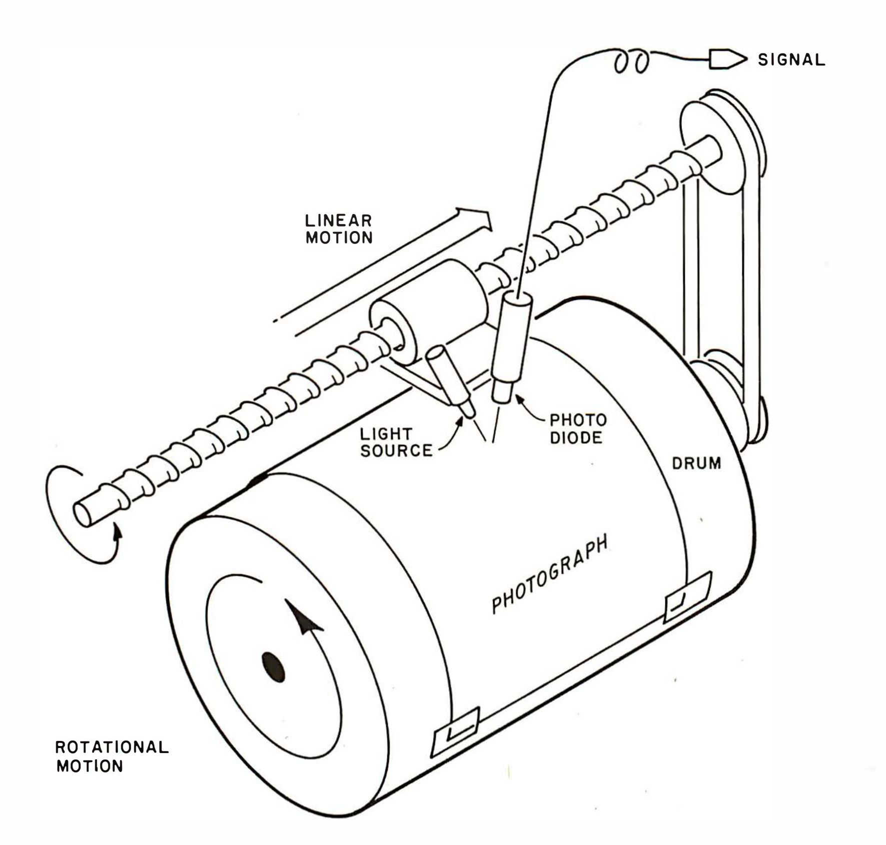


Figure 1: *A drum scanner produces high-quality results by moving the photograph relative to the sensor. Its drawbacks are that it requires precision mechanical construction, works very slowly, and the signal it produces is not video-compatible.*

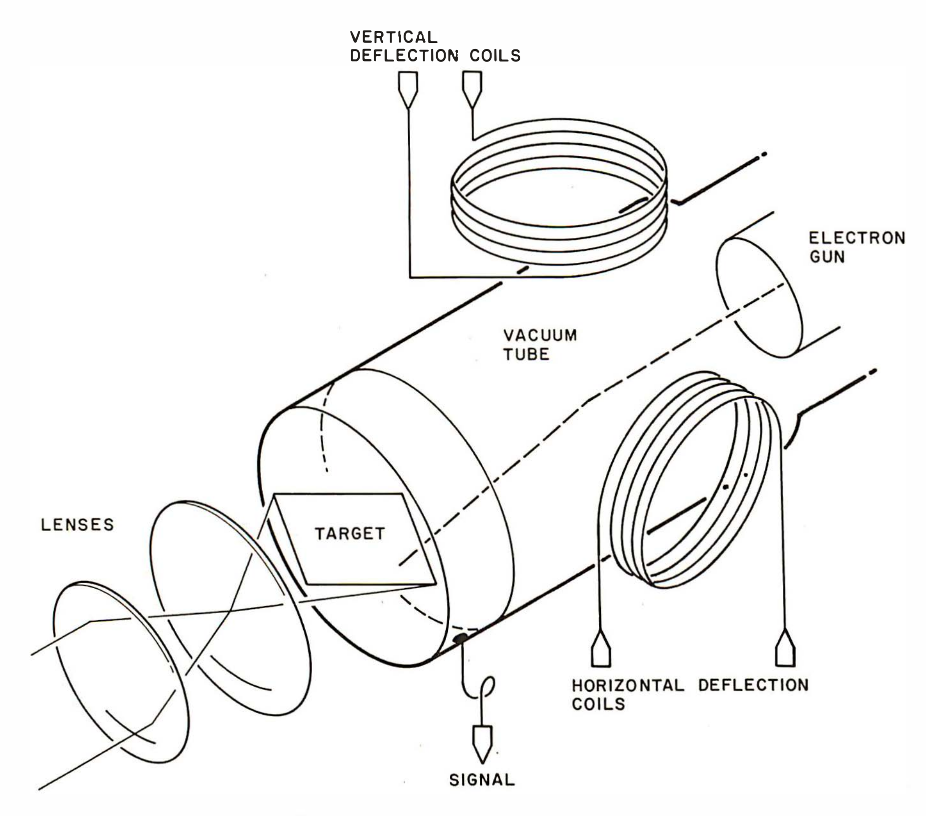


Figure 2: *A vidicon tube. This most popular method of converting an image into an electronic signal uses a photo-sensitive imaging target which is scanned by an electron beam. The resulting signal is the scanned image in the form of a changing voltage. Disadvantages of the vidicon are its unstable geometry (since electron-beam deflection is never completely repeatable and accurate) and its low resistance to shock (since vidicons are vacuum tubes).*

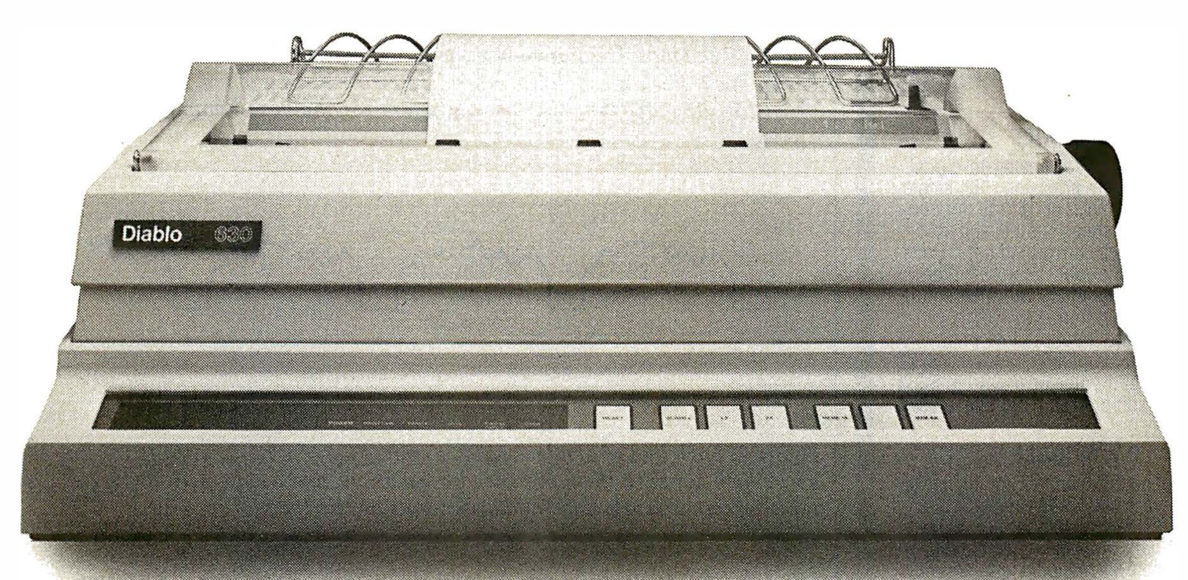
age as much as 20%. This error (also called *shading*) is still present in more expensive cameras where it's typically reduced to 10% or less. Fortunately, the shading effect changes slowly across the image target. Actual defects in the target are often found in inexpensive cameras, leading to black or white spots in the image.

It is possible to make some correction for the effects of shading and defects after the image is quantized. To do so, you first quantize an image of a solid-gray surface. The deviation of each point's value from the average value indicates the amount of correction that is necessary. By storing this image (or an image of corresponding correction values) the recorded target sensitivity can be used to improve the quality of another image quantized from the same television camera.

A television camera is to an image-capture system as an antenna is to a television set. No matter how much effort is spent on improving the system, the results are only as good as the input. Although the system can be made to compensate for some of the deviations in the camera, improvement of the video source is usually the choice for further investment once an image-capture system is in place.

A video image is normally generated in a 4:3 aspect ratio. This means that a properly operating camera produces it in a format that must be presented on a screen with three units of height and four units of width. Typical television sets are adjusted to approximately this ratio. If the video signal is quantized into a square array of square pixels, only a portion of each line should be quantized. (See figure 5.) Because there are approximately 512 lines of useful video image in a frame (approximately 256 lines in a field), it is often convenient to work with 512 or 256 squared resolutions. Some manufacturers of quantizers offer nearly square pixels by quantizing during 3/4 of the horizontal period, while others offer square pixels by digitizing the entire image at 640 by 512, 320 by 256, or other resolutions. Still others offer rectangular pixels. To achieve square pixels, the sampling rates must be increased by a factor of 1.33. If the entire image is to be quantized with square pixels, the memory requirements must also be increased by a factor of 1.33.

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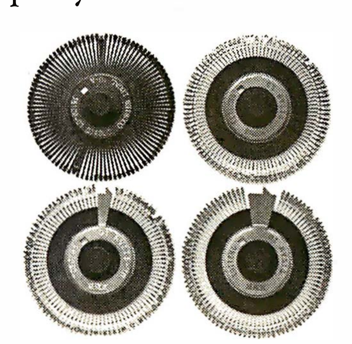


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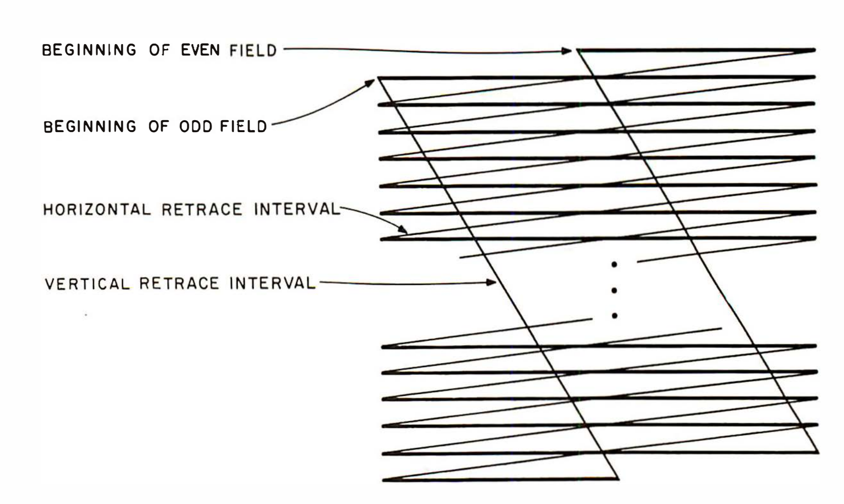


Figure 3: *Video lines are interlaced in a 2:1 ratio to reduce image flicker. Each frame of a video image (1/30 second) is made up of two fields. During the first 1/60 second the even-numbered lines are scanned, followed by the odd-numbered lines during the second 1/60 second. The luminance signal (black-and-white intensity) is indicated by the heavy lines. The narrow lines indicate intervals during which the electron beam is off in order for the deflection circuits to prepare for the next luminance signal.*

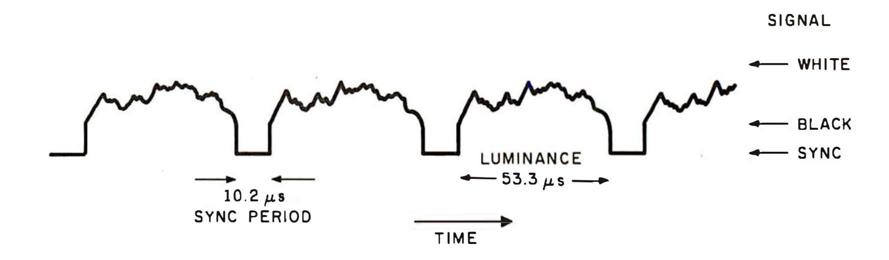


Figure 4: *Each line of a video signal is composed of a horizontal active-line period (53.3 μs), which contains the luminance information, and a sync period (10.2 μs), which contains reference levels and the horizontal sync period.*

Noise and Averaging

Video signals, like all signals, contain noise. It arises from several sources, primarily the circuits which amplify the sensor output. Very high quality video sources can have signal-to-noise ratios exceeding 45 dB. This is approximately equivalent to a noise of ±½ the least-significant bit in a 7-bit quantization. However, many inexpensive home cameras, videotape, and off-the-air sources often exhibit signal-to-noise ratios worse than 25 dB or about ±½ the least-significant bit in a 4-bit quantization. Why is it that such noisy video is still quite acceptable to a viewer? The noise is random; it changes every 1/30 second; and the eye averages out the noise. If you carefully view still video frames, such as on television sports events, the noise becomes apparent.

To improve the noise figure and the quality of the captured image, a number of frames can be pointwise averaged. Several frames are used to accomplish this: the first frame is digitized and stored; the second and successive frames are digitized; and each value is added to the corresponding stored value. The resulting array of numbers is divided by the number of frames used. Thus, the value for each point becomes the average of digitized values for that point across all the frames used, effectively cancelling out random noise. The improvement can be quite dramatic in situations where considerable noise is present. One can expect to achieve about $6.3 \times \log_2 N$ dB improvement for N frames up to a practical limit of about 45 dB. This maximum figure depends on the signal source, and the improvement depends on the randomness of the noise.

Sampling

The process of quantization consists of a sampling and a digitization phase. The sampling phase determines exactly when the signal value is to be frozen in time so the instantaneous value can be converted into a

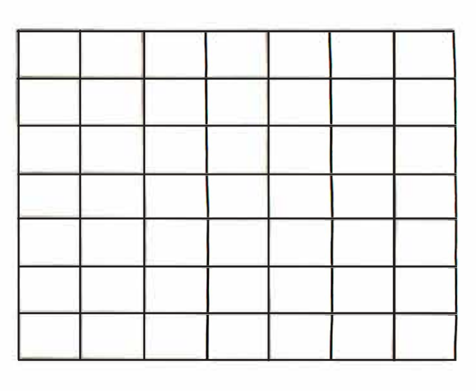
number (ie: digitized). The sampling function is accomplished by periodically pulsing a sample circuit. The value of the video signal is then used to charge a capacitor that holds that value during the time needed by the digitizer until the next sample pulse. A sample-and-hold circuit provides the necessary components in hybrid or monolithic form. (See figure 6.)

The choice of sampling rate determines the spatial resolution with which the video signal is quantized. The sampling theorem tells us that a sample frequency must be chosen that is at least twice the value of the highest frequency component in the signal that we wish to record. Thus if we choose to sample at 10 MHz, or once every 100 ns, we will be able to record components of the video signal which are changing at rates up to 5 MHz. Sampling at this rate guarantees adequate data for all normal black-and-white video sources, since they contain very little energy beyond 4 MHz.

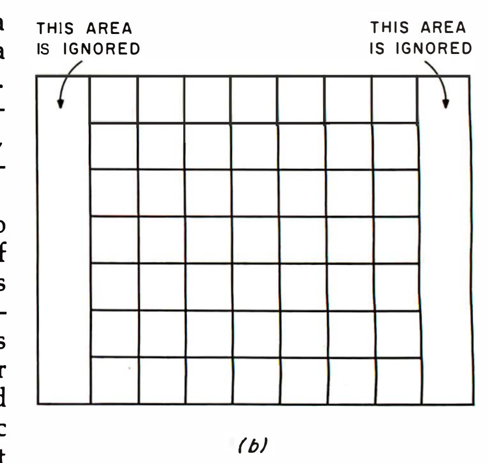
Examination of the sampling process shows that if there are frequency components in the signal above half of the sampling rate, false information (called *aliasing*) results. (See figure 7.) The aliasing component is effectively a beat frequency between the sampling frequency and the signal components above *half* the sampling frequency. In the case of standard video, the luminance signal is already filtered to roll-off in amplitude above 4 MHz. However, the chrominance signal in color video occupies the range from about 3 MHz to 4.5 MHz.

Therefore, you must either filter the signal to remove frequencies above about 3 MHz, derive a pure luminance signal from a properly designed video demodulator, or use a strictly luminance source, such as a black-and-white television camera. When digitizing at lower resolutions (and sampling at lower rates), the signal must be filtered accordingly.

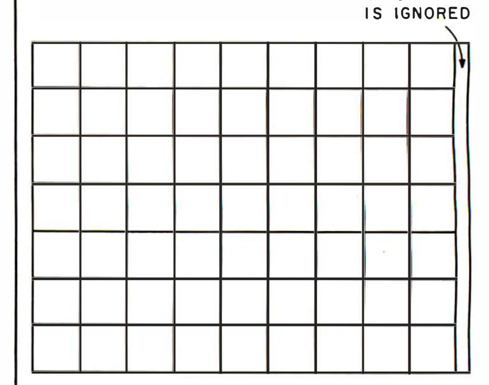
The quality of a quantized video signal depends on accurate timing. If every element of the digital image is to be precisely aligned with the corresponding element in the video lines above and below it, the digitizer clock must be precisely synchronized with the television horizontal-sync signal. Also, the digitizer clock must not drift during the time between



(a)



(b)



(c)

Figure 5: *The aspect ratio (width:height) of normal video is 4:3. The aspect ratio of each individual pixel is determined by the image-sampling rate.*
a: *This 7 by 7 square array of rectangular pixels is produced by sampling the same number of points per line as there are lines in a frame. For example, each line in an American-standard television frame (512 lines) would be scanned as 512 points.*
b: *By increasing the sampling rate by 1.33, square pixels result and a 7 by 7 array results from a square portion of the frame.*
c: *With the same increase in the sampling rate as in* **b**, *nearly the entire frame can be quantized into a 9 by 7 rectangular array of square pixels.*

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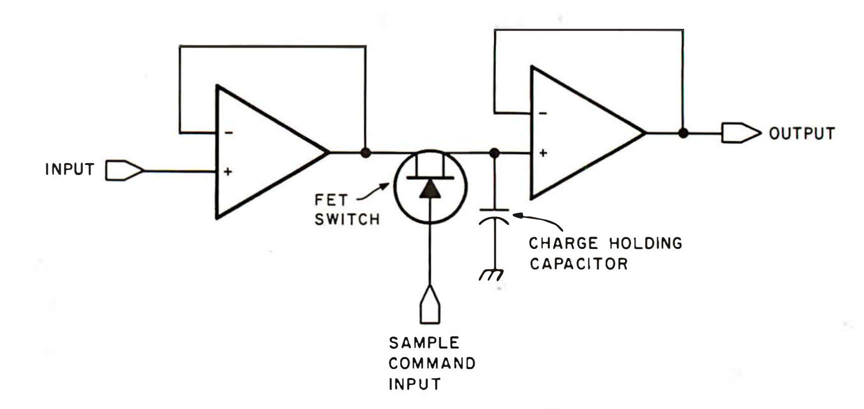


Figure 6: *An image is quantized in two phases: sampling and digitization. Sampling freezes the signal value so that it can be converted into a number (digitized). A sample-and-hold circuit such as shown here performs the sampling phase. Because of the low output impedance of the first operational amplifier, the capacitor is charged nearly instantaneously when the switch is operated by the video signal. The high input impedance of the second operational amplifier holds the capacitor at its full charge during the time the digitizer reads the signal.*

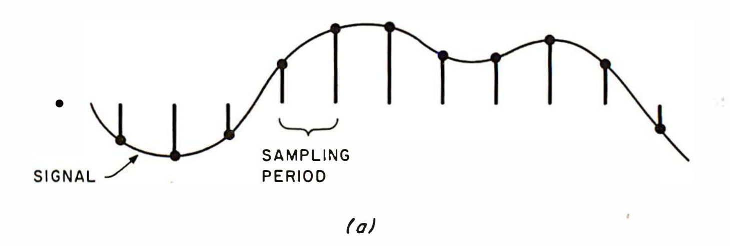


Figure 7a: *A correctly sampled video signal. Each dot indicates an instantaneous value read by the digitizer.*

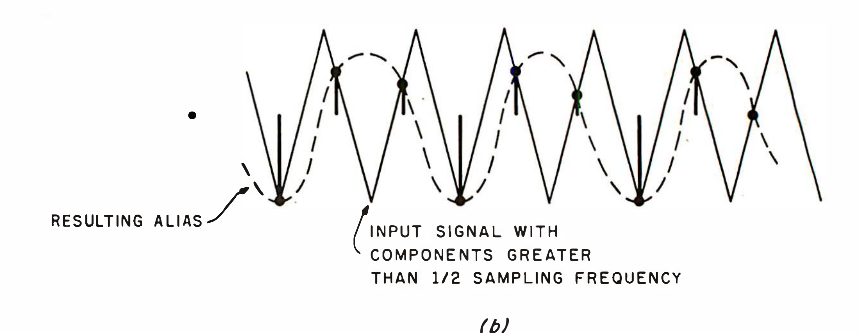


Figure 7b: *If high-frequency components are present in the video signal which are above one-half the sampling rate, false information (aliasing) results. Aliasing is a beat frequency between the sampling frequency and those signal components above one-half the sampling frequency. A low-pass filter is used to filter the frequency components and eliminate aliasing.*

horizontal-sync pulses. It is as much the attention to timing as to the high-speed technology that makes quality digitized video a reality.

Low-Speed Digitization

The digitizer, or A/D (analog-to-digital) converter, is commonly thought of as a device that takes on the order of 20 μs to 50 μs to determine an 8-bit or 12-bit value. Such converters are inexpensive and are adequate for sampling slowly changing signals, such as an audio signal.

To digitize a video signal with such a converter, you can sample the signal no more often than about once per scan line. (See figure 8.) During the first frame, the first point of each line is digitized. During the second frame, the second point of each line is digitized, and so forth, until the entire image is digitized. If 512 samples per line are needed, 512 frames of video would be required to digitize every point. Thus, it would take about 17 seconds to complete the digitization of one frame. To do this the camera

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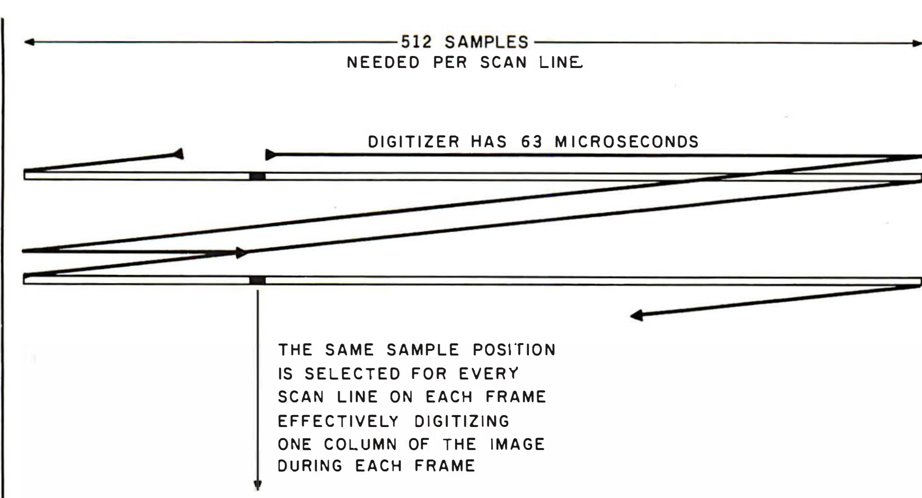


Figure 8: *By sampling a single point per scan line, the digitization of each pixel can be completed within 63 µs, and data is produced at a slow enough rate (15.7 k bytes/second) for transfer to mass storage.*

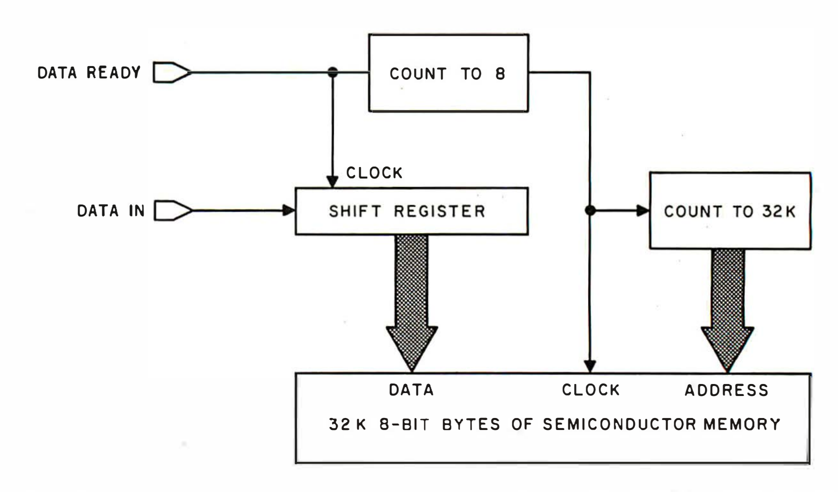


Figure 9: *Through the use of a shift register, standard programmable memory can be used to transfer a single-bit image at video rates. If a single bit is deposited into the shift register every 100 ns, an 8-bit value can be deposited into memory every 800 ns. The same process can be reversed for displaying the image.*

must be stationary on a tripod with respect to the object being viewed to keep the image stable. Tape players with freeze-frame options might seem attractive for this purpose. However, home videotape machines do not produce a truly stable image and are not usually adequate for this purpose.

The digitizer has plenty of time to produce a digital value. Precision is defined by the number of quantization levels, and more can be obtained for a small additional cost. Unfortunately, the sample circuitry must sample a very precise portion of the video signal, and its accuracy becomes more important if greater quantization levels are desired. Additionally, the decay rate of the sample circuitry becomes important because the sample must be held for up to 50 µs versus the 100 ns necessary for the high-speed digitization technique.

The advantages of slow digitization are the use of a relatively inexpensive A/D converter and low data rates, permitting direct storage of the data using floppy disks. The disadvantages are the need to hold the camera and scene stable for a length of time (depending on resolution) and the inability to capture other video sources, such as television programs and videotape. The requirements for the sampling phase are also more substantial than those for the high-speed method.

There is a hidden disadvantage of the low-speed method. The stored image cannot be readily viewed by reversing the process. The only way to reproduce the data in image form is to place a photographic camera in

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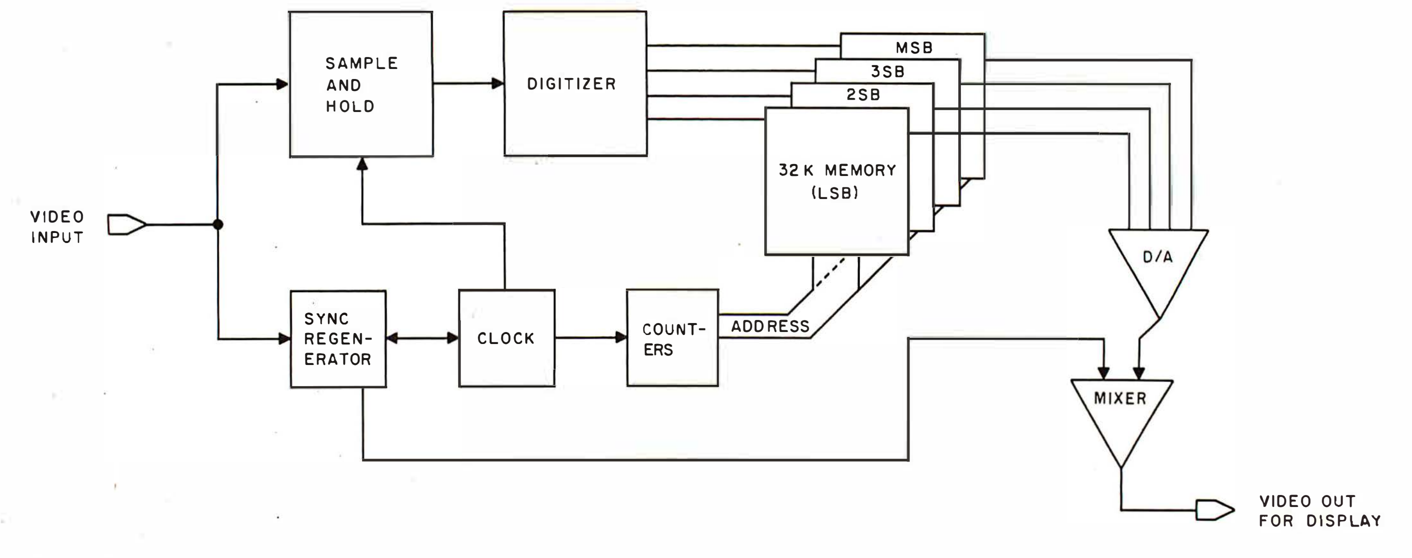


Figure 10: *Block diagram of an image-quantization system. In this example, a single memory board is used for each bit of quantization. Four boards would be needed for a 4-bit quantization.*

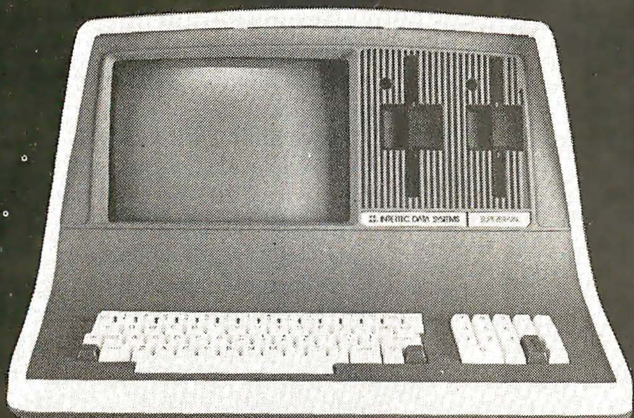
front of a television monitor and open the shutter for 17 seconds while the data are converted back into video, one point per line. Then, of course, the film must be processed: this is hardly conducive to interactive use.

High-Speed Digitization

If we want to digitize 512 points during each scan line, the converter must operate at very high speeds. The active portion of a video line is about 53 μs. Roughly, this means it must quantize the signal once every 100 ns. Such converters were available 10 years ago for about $2000, but today they can be built for less than $100! Next I'll examine the problems of storing the data produced at this rate.

Most home computers have central memory that can be cycled at about 250 ns to 1000 ns per 8-bit transfer. If the digitizer obtains one 4-bit quantity every 100 ns (at 512 samples per line with rectangular pixels), or 8 bits every 200 ns, standard computer memory cannot cope with the speed requirement. Most experimenters own configurations with 32 K bytes

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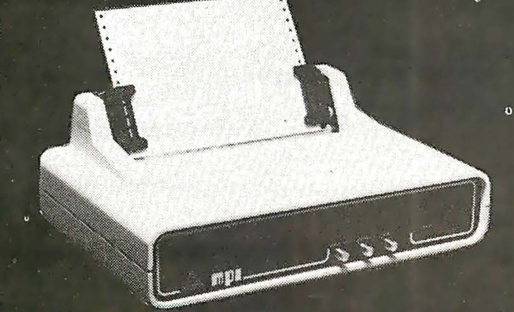
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or less of central memory. Although 32 K bytes would be barely sufficient for a 256 by 256 4-bit image, 128 K bytes are necessary for a 512 by 512 4-bit image. Therefore, memory is usually dedicated to the image-storage function and accessed by the computer through either a processor-controlled or DMA (direct-memory access) port.

The problem of providing large memories capable of 200 ns cycle times can be solved by the sequential nature of data transfers. By dividing memory into a number of parallel segments it's possible to use memories with 800 ns read/write-cycle times to simultaneously digitize, display, and communicate with the computer.

Proper memory organization allows ease of expansion, depending on whether higher spatial resolution or more bits per picture element are anticipated in the future. Also, good designs can be software-reconfigured to trade off spatial resolution for the number of bits per pixel. Methods for reconfiguration are left for the ambitious designers to discover on their own.

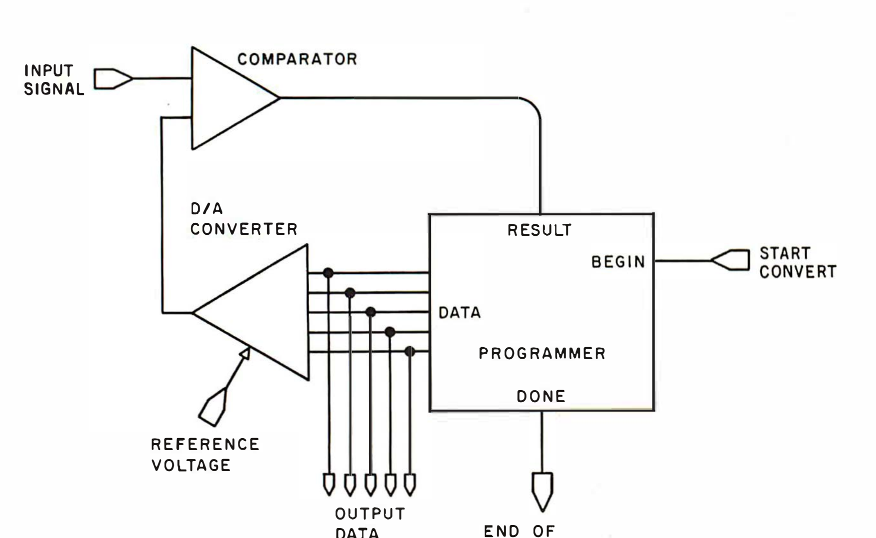


Figure 11: *The configuration of a conventional A/D converter.*

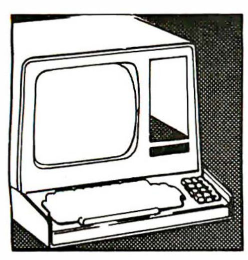
A Hypothetical Design

Assume that we'll require a 512 by 512 image with 4-bit quantization of each pixel. Memory is physically organized as four 32 K-byte memory boards. This is because there are 256 K points in the image, and we wish to have 1 bit of each 4-bit pixel value on each memory board. We will use memory which transfers 8-bit quantities.

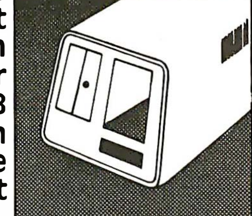
If we shift 1 bit every 100 ns into a serial-in, parallel-out shift register, then every 800 ns the resulting 8-bit value can be deposited into memory. (See figure 9.) The same process can be reversed for real-time display. To do so, the memory is read every 800 ns, the 8-bit value is placed into a parallel-in, serial-out shift register, and shifted out at 100 ns per pixel.

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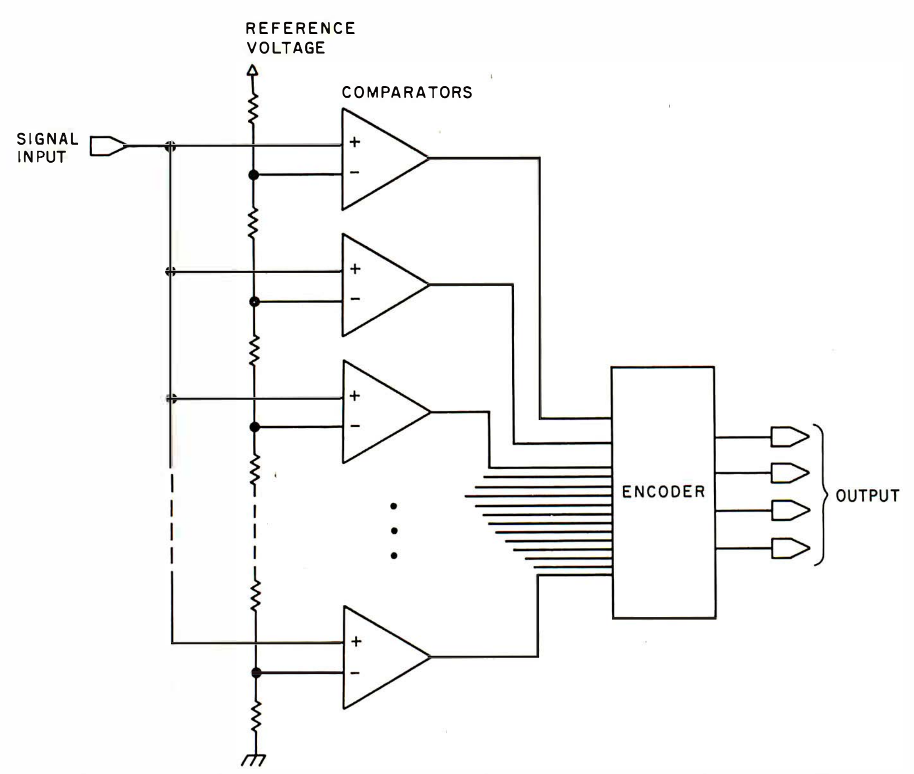


Figure 12: *The small number of bits required for image quantization makes flash (or parallel) A/D conversion practical. One comparator is used for each quantization level. For a 4-bit quantization, sixteen comparators would be needed. A reference voltage equal to full scale is fed to a voltage divider to form a set of comparator thresholds. The output of each comparator is then fed to the encoder, where the number of on comparators is converted into a binary output. Parallel converters are available in DIP form and allow for high data-conversion rates.*

To achieve the desired number of quantization bits per pixel, we stack the appropriate number of memory boards. (See figure 10.) In our case, four boards would be needed for 4-bit pixels. Of course, there would have to be an address bus common to all boards and an extra board to provide control and A/D conversion. The extra board would be needed to decode the video sync signals to keep memory-addressing in step with the video signal. Additionally, D/A (digital-to-analog) conversion and sync generation are necessary to drive a display monitor.

Notice that the memory is running at very slow speeds by modern standards. If we use memory that allows *two* operations per 800 ns, the computer can access or deposit data completely transparent to the digitization or display process.

Now consider high-speed A/D converters. Normal converters use a D/A converter, a programmer, and a comparator to derive a numerical quantity representing the voltage on the input. (See figure 11.) The programmer tries successive numbers, generating successive voltages out of the D/A converter. These voltages are compared with the analog input to determine if they are above or below the input voltage. The comparator output is used by the programmer to decide what number to try next until the process converges on a final value.

The fastest A/D programs take about as many tries as there are bits of quantity. Each try consumes as much time as the total of the programmer gate delay, the D/A-gate delay, the D/A-settling time, and the comparator-settling time. The fastest converters perform conversion on the order of the 100 ns per bit. This is obviously unacceptable for our purposes, since we consider 4 bits to be a minimum quantization and 100 ns to 200 ns to be a maximum conversion time.

The small number of bits that are required does make another conversion technique very practical. It has several names, the most popular being *flash* or *parallel* conversion. It consists of one comparator for each quantization level, or sixteen comparators for 4 bits. (See figure 12.) A reference voltage equal to full scale is fed to a voltage divider (ie: a network of resistors) to form a set of comparator thresholds, and the outputs

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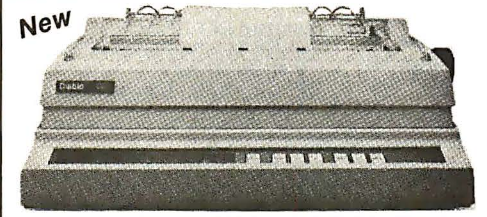


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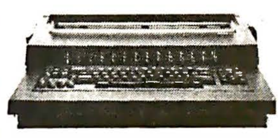


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The Nature of Video Images

The video standard has three primary components, synchronization signals, a luminance (black-and-white) signal, and a chrominance (color) signal. The synchronization (sync) signals tell the receiver when to begin a new frame and a new line. The luminance signal provides intensity values that comprise a picture. The signals are effectively separate, allowing compatibility between color and black-and-white television receivers. Our primary interest here is the luminance signal, but the chrominance signal must still be considered. It must be filtered out of a color video signal before quantization. (The reason for this requirement has been described in the section on sampling.)

Each complete picture, called a frame, *takes 1/30 second to complete. To reduce flicker, 2:1 interlacing is used. During the first 1/60 second, the even-numbered lines are displayed; and during the second 1/60 second, the odd-numbered lines are displayed. Each set of lines (half of the frame) is called a* field. *(See figure 3.)*

Each field consists of 262.5 lines, each line transmitted in 63.5 µs. Nine of these lines are used for the vertical synchronization pulse, which is actually a series of pulses that are easy for receiver circuits to recognize. Each line is composed of a horizontal active-line period during which luminance information is present, and a sync period when reference levels and the horizontal sync signal are present. The horizontal active period is 53.3 µs, and the sync period is 10.2 µs. (See figure 4.)

of the comparators are fed to an encoder. The analog voltage determines which comparators are on, and the encoder then turns the number of on comparators into the corresponding binary number. The only delays are the settling time of one comparator and the encoder-logic delay. I've built three of these for under $100. They are also commercially available in DIP (dual-in-line package) form in 3-bit or 4-bit designs that allow for cascading to achieve 1 or 2 additional bits.

Summary

Inexpensive semiconductor memory and other technological developments have made digital image storage with real-time video input and output a practical reality for the home computer experimenter. Several complete hardware and software systems are available for the display and digitization of real-time video. At least one company offers an inexpensive, real-time digitizer and display, while several offer very inexpensive digitizers to accomplish low-speed digitization. A high-speed system costs $1500 to $5000 or more, depending on options. The primary price difference is due to the amount of image memory desired. Low-speed systems range from about $350 to $4000.

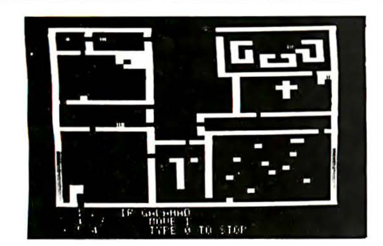
Flash-conversion products range from $30 to $90 for 3-bit and 4-bit units with about 30 MHz maximum rate. These save you the headaches of finding matched resistor values for homebrew flash converters.

Although there isn't enough information in this brief article to construct an image-capture system, there should be enough to familiarize an ambitious designer with the techniques and problems. You would be well advised to obtain a technical manual from a manufacturer to help assess the potential difficulties. With healthy competition in the growing marketplace for image-capture and display, the power/price ratio of complete systems will continue to increase. ■

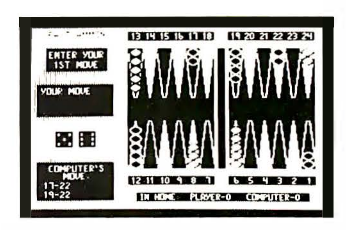
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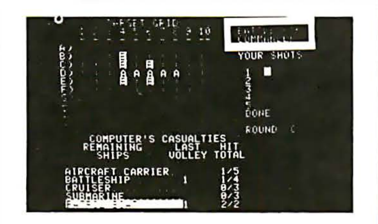
If you liked "Invaders", you'll love ASTEROIDS IN SPACE by Bruce Wallace. Your space ship is traveling in the middle of a shower of asteroids. Blast the asteroids with lasers, but beware — big asteroids fragment into small asteroids! The Apple game paddles allow you to rotate your space ship, fire its laser gun, and give it thrust to propel it through endless space. From time to time you will encounter an alien space ship whose mission is to destroy you, so you'd better destroy it first! High resolution graphics and sound effects add to the arcade-like excitement that this program generates. Runs on any Apple II with at least 32K and one disk drive.
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BYTELINES

NEWS AND SPECULATION ABOUT PERSONAL COMPUTING

Conducted by Sol Libes

DEC Opens Computer Museum: Digital Equipment Corporation (DEC), the pioneer in minicomputers, has opened a "computer museum" in the lobby and mezzanine level of its Marlboro, Massachusetts, "Tower Building." It illustrates, through actual equipment, the evolution from calculator to microcomputers. The exhibits include precomputer devices, the four generations of digital logic used in computers, and some early computer systems (eg: PDP-1 with the original *Spacewar* program and others). The museum is open to the public.

Random News Bits: Casio, Inc, the Japanese electronics manufacturer, has introduced a personal computer in the US. The FX-9000P can store programs directly in 4 K-byte CMOS (complementary metal-oxide semiconductor) memory cartridges (with lithium batteries) that can be removed from the unit. The basic unit is priced under $900.... Pascal can now be considered as having "made it." IBM has announced that Pascal will be available for IBM systems using OS/VS and VM/CMS operating systems. IBM will charge $235 a month for it. To think that most microcomputer users pay less than IBM's monthly charge to buy Pascal outright.... A study conducted by the National Institute for Occupational Safety and Health found that video-terminal users suffer problems of eye strain, blurred vision, color perception, numbness, and loss of strength in their arms. These users also experience higher levels of anxiety, depression, confusion, and fatigue....The University of Southern California will offer a graduate degree in voice I/O (input/output). The curriculum includes courses in electrical and biomedical engineering, communications, computer science, linguistics, otolaryngology, and psychology...

Fujitsu Overtakes IBM In Japan: For the past thirty years, IBM has dominated data processing over the entire globe. Now, however, it is reported that in Japan Fujitsu, Ltd, has overtaken IBM in sales. Fujitsu and several other Japanese computer suppliers are now preparing a massive onslaught into the US and European markets.

IEEE Local Network Standard Moves Ahead: The IEEE Local Network Standards Committee expects to have a draft of its standard by year's end. At this time, it appears that the Ethernet system, proposed by Xerox, Digital Equipment Corporation, and Intel, will *not* be adopted as the standard. The reasons for this are that Ethernet is still in a preliminary-definition state with many areas not precisely defined. Further, Ethernet is highly dependent on coaxial cables and a particular modulation technique. Also, Ethernet does not have any provision for acknowledging datagrams, which could lead to possible incompatibilities in error control between different manufacturer's devices.

Super Computer Planned: The Ames Research Center of NASA (National Aeronautics and Space Administration) is planning a special super computer capable of performing a billion floating-point operations per second. The computer will be designed to simulate a wind tunnel. It is expected to have 40 M words of directly addressable memory plus 200 M words of block-addressable memory. NASA wants the system operational in 1986.

US Government Shifting To Smaller Computers: The US government now has a reported 15,000 computers in operation, worth more than $5.4 billion. The trend is shifting from large, costly mainframes to smaller units. In fact, now at least two-thirds of the machines cost less than $50,000.

The GSA (General Services Administration) recently disclosed that at the end of 1979 the three leading computer suppliers were Digital Equipment Corporation (3656 units), Sperry Univac (1778 units), and IBM (1284 units). However, IBM still ranked number one in dollars ($1.45 billion), Control Data was second ($754 million), and Sperry Univac was third ($686 million).

Ribbon Recycling: The word-processing and printer markets have created the new business of recycling printer ribbons. About fifty vendors are offering consumers recycled ribbons at a saving of as much as 60%, along with deliveries in 5 to 10 days.

Several ribbon manufacturers are introducing sealed ribbon cartridges to prevent recycling. They claim that sealing improves ribbon reliability.

Microsoft Signs UNIX Agreement: Microsoft, of Bellevue, Washington, has signed an agreement with Western Electric for the rights to develop and market versions of UNIX, an operating system originated by Bell Laboratories. The Microsoft versions will be specifically designed for 16-bit microprocessors, such as the Intel 8086, Zilog Z8000, and Motorola 68000. The Microsoft version will be called XENIX. UNIX seems to be the most popular minicomputer timesharing operating system in current use. It is very popular in the educational community, probably because Western Electric sold it to educational institutions for a very low fee. However, due to its sophisticated features, UNIX has been gaining in popularity in the profes-

sional and business worlds as well.

Microsoft plans to charge an initial fee for the package ranging from a low of $500 to $3000 for a four-user system. The company also has plans to adapt its BASIC, FORTRAN , and COBOL compilers to run under XENIX. Microsoft has purchased a DEC PDP-11/70 minicomputer specifically for the XENIX development project. The Z8000 version is slated for introduction by year's end, and the 8086 and 68000 versions are to follow sometime in the second quarter of 1981.

Considering that Digital Research plans on developing only an 8086 version of its very popular CP/M operating system, it seems likely that Microsoft's XENIX will become the dominant operating system for 16-bit microcomputer systems.

5-Inch Winchester Disk Drives Coming On Strong: At least a half-dozen companies will have 5-inch hard-disk drives on the market late in the first half of 1981. Latest to jump on the 5-inch disk-drive bandwagon are International Memories Inc (IMI) (the Cupertino, California, firm that marketed the first 8-inch Winchester drive) and Shugart Associates (the largest producer of floppy-disk drives). These drives typically store 5 million to 7 million bytes and sell for less than $1000 in OEM (original equipment manufacturer) quantities.

64 K-Bit Memory Devices Becoming Available: Several integrated-circuit manufacturers are currently supplying samples of the new 64 K-bit programmable memory circuits to OEMs for evaluation and development. Look to see these devices in use starting in early 1981.

The introduction of these components has already caused the price of 16 K-bit devices to drop significantly; just a few months ago, these circuits cost six to eight dollars—now they are four or five dollars. Currently, the 64 K-bit memories are in the forty- to sixty-dollar range, which may drop to thirty or thirty-five dollars in production quantities.

It is expected that Japanese suppliers will dominate the 64 K-bit device marketplace. The 16 K-bit device market has been dominated by American suppliers, although the Japanese currently have 40% of that market. The demand for the 64 K-bit memories does not, as yet, appear to be very strong. However, the price erosion of the 16 K-bit memories and increasing competition from Japanese suppliers should cause the 64 K-bit memory prices to drop quickly.

Protecting The Software Copyright: Software vendors are very concerned about software being pirated by unauthorized copying. The problem is acute simply because it is very easy to duplicate cassette- and disk-based software. Further, it isn't especially difficult to copy software stored in read-only memories.

The personal-computer user does not appear to be the cause of the problem because most of that type of pirating is for personal use, and it occurs only on a small scale without a significant impact on vendor sales. However, several software vendors are complaining that software pirates are making copies of their software packages and selling them. The software pirate frequently changes the name of the software package and may even make some minor changes so that the consumer is unaware that the software is a fraud. The practice appears to be widespread outside the US, where this kind of activity is very difficult to prevent.

As a result, software vendors are seeking ways to prevent pirating. Several are now experimenting with software techniques that cause the copied software to self-destruct if it is run on an unauthorized machine. I suspect that this will prove to be a deterrent for the experimenter and small-time thief, but the professional software pirate should be able to overcome this system.

Tandy, Apple, And Commodore Are Top Personal-Computer Performers: Each year *Datamation* analyzes and rates the top one hundred computer companies. For the second year in a row, Tandy Corporation (parent company of Radio Shack), Apple Computer, and Commodore have made that list. In fact, for this past year Tandy ranked thirty-ninth (up from last year's fifty-eighth), Apple ranked sixty-first (up from one-hundredth last year), and Commodore ranked seventy-fifth (up from ninety-fourth last year). Tandy had gross sales of $150 million, a 131% increase. Apple had $75 million in sales, up from $10 million the previous year, a 650% increase. Commodore had $55 million sales, a 150% increase.

These three personal-computer makers had the highest growth rates of the top one hundred computer-product vendors in the US. IBM, which ranked number one in total sales, had only a 7% increase in sales.

Talking Computers To Be The Rage: 1981 should be the year that consumers first see the widespread use of voice output in products ranging from computers to household appliances. Many manufacturers are currently supplying samples of speech-synthesis integrated circuits to OEM customers. The manufacturers include Texas Instruments, National Semiconductor, General Instrument, Hitachi, and Votrax. The Hitachi HD38880 integrated circuit, for example, can produce up to 200 words or one hundred seconds of speech from data stored in a 128 K-bit ROM (read-only memory). The Texas Instruments TMS5200, essentially the same device used in the Speak & Spell toy, has been given an 8-bit data-bus interface and should operate easily with personal computers.

Random Rumors: It is rumored that Intel, Motorola, and Fujitsu are all working on the development of microprocessors that will implement the IBM System/370 instruction set. Performance is expected to be comparable to an IBM 370/115. IBM is rumored to already have such an integrated-circuit version running.... Xerox is rumored to be attempting to buy Apple Computer.... Digital Equipment Corporation is rumored ready to release a 16-bit microprocessor device that will be compatible with 8080, Z80, and 6800 support circuits. It is expected to have the power of a PDP-11/23. At least one company is rumored to be investigating an S-100 implementation....

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Machine Problem Solving

Part 3: The Alpha-Beta Procedure

Professor Peter Frey
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Evanston IL 60201

Zero-Sum Games

In many problem-solving situations, the wisdom of a particular decision often depends upon the range of options that someone else may have. Many real-world decision-making environments can be modeled in terms of a two-person game. When each player is aware of his own and his opponent's options at each choice point, the game is described as one of *perfect information*. If the rules of the game require that each player's gain must come at the expense of the other, then the game is strictly competitive, or *zero-sum*. Familiar games that meet these criteria are chess, checkers, three-dimensional tic-tac-toe, go, gomoku, and Othello.

The first two articles in this series considered decision-making situations in which a single individual was responsible for a series of choices. By constructing programs that searched among a large number of choice combinations, we were successful in developing mechanical solutions for these problems. When two people are making choices and each is trying to better his own position at the other's expense, the standard look-ahead search that we described earlier is no longer adequate.

Minimax Strategy

Instead, it is necessary to consider choices in which the two players attempt to satisfy conflicting goals. Most of the important strategic ideas which are used in analyzing these games date back to a very influential book which was written in 1944 by Von Neumann and Morgenstern (see reference 4).

The key idea for our present purposes is the *minimax* strategy. In analyzing any given position in the game, a look-ahead tree is constructed which represents the sequence of options that the two players have (as a hierarchical branching structure which grows exponentially as one proceeds away from the initial position).

The minimax strategy consists of evaluating "final" positions at some arbitrary depth (usually defined by practical constraints of time and space) and then following parent nodes all the way down the tree to the starting position. This path is defined by assuming that each player will decide among the options that are available to him at *his* choice points by selecting the one that guarantees the best possible outcome.

If the terminal evaluations are chosen such that high numbers favor the first player (and low numbers favor the second player), the first player is expected to choose the pathway that guarantees as large a terminal value as possible, and the second player is expected to choose the pathway that guarantees as small a terminal value as possible. In practical terms, the first player always maximizes, the second player always minimizes.

This description would seem to explain the derivation of the name. This is not historically correct, however. The "minimax" name is actually based on the underlying strategic idea that each player attempts to minimize his opponent's maximum potential gain.

History and Practicality

The minimax technique appeared to be of limited practicality when it was first discovered because of the rapid increase in the number of terminal positions as the look-ahead tree grows. The number of terminal positions that need to be analyzed in a minimax search is equal roughly

to the average number of options at each choice raised to a power equal to the depth of the search tree. For example, consider the game of chess, which averages thirty-eight options at each choice point. A minimax search considering a look-ahead of four moves for each player would have 38^8 terminal positions. That is more than 4 trillion (4,000,000,000,000) positions.

You do not have to be a mathematical genius in order to determine that a process that grows exponentially like this one is going to get out of control very quickly. Because of this exponential explosion and because there were no computers in the 1940s, the minimax algorithm initially received little attention.

> In practical terms, the first player always maximizes, the second player always minimizes.

The Alpha-Beta Technique

In 1956, at the Dartmouth Summer Research Conference on Artificial Intelligence (see reference 1), John McCarthy pointed out that Bernstein's chess program did not need to analyze all of the terminal positions in order to select the move that was best in terms of the minimax strategy.

Although no formal description of the idea was given at that time, several of the game-playing programs written in the late 1950s appear to have employed an enhanced version of the minimax procedure, which has come to be called the α-β (ie: alpha-beta) pruning algorithm. The name seems to have been coined by McCarthy.

The first clear description of the technique for English-speaking audiences was published in 1969 by Slagle and Dixon (see reference 3). The α-β procedure provides a remarkable increase in the efficiency of the search process; and, with the advent of the high-speed computer in the late 1960s and 1970s, the minimax idea finally came of age.

Although there are many references to the α-β minimax technique in the popular literature, the procedure has not received much detailed analysis in the academic literature. The best expository presentation on this topic is a recent paper by Knuth and Moore (see reference 1). The technical details that enhance the efficiency of the α-β strategy are scattered throughout a number of hard-to-find sources. The purpose of this article is to summarize the main ideas and to present a sample program with the key algorithms.

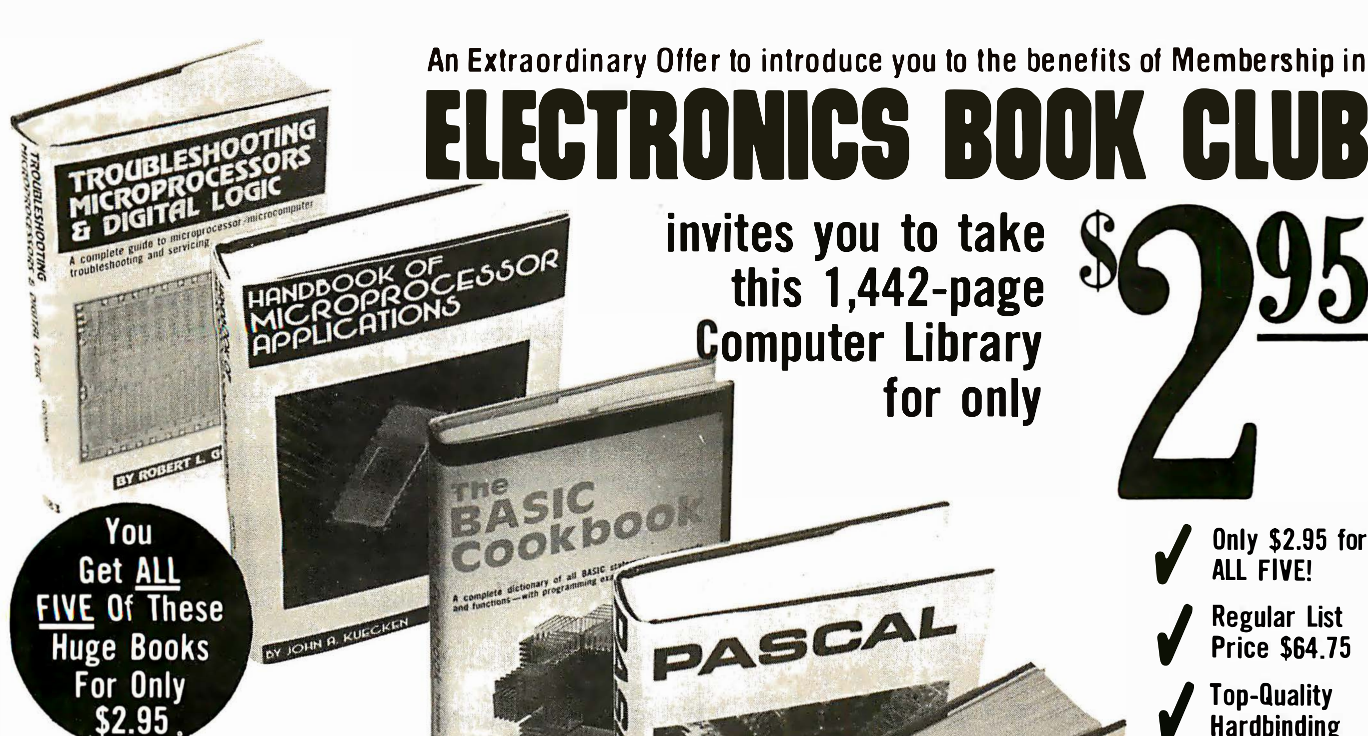
Treasure Search

To provide an explicit example, I have devised a new game that is easy to play and is easily programmed. One of the difficulties of describing the α-β minimax procedure within the context of a familiar game is that move generation and position evaluation are sufficiently complex that these aspects of the program tend to mask the fine points of the α-β search. The game we will consider involves very straightforward move-generation and position-evaluation routines. For this reason, we will be

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able to concentrate on the tree-searching algorithm in the absence of unwanted distractions.

This new game is called Treasure Search and is played on an 8-by-8 grid. A digit between 1 and 9 is randomly assigned to each of the sixty-four squares. Each contestant has a single playing piece which is initially positioned in the central portion of the grid. The players take turns moving their pieces. A piece can be moved only one square at a time in one of four orthogonal directions (ie: north, south, east, or west). The object of the game is to visit squares where a large number has been assigned and to collect as many of these as possible. Once a number has been taken from a square, that location is empty and subsequent visits provide no additional benefits. The first player to accumulate one hundred or more points wins the game.

```
Treasure Search 4

                 8  6  1  7  5  8  9  6
                 4  9  5  6  2  6  9  1
George           4  1  4  6  4  7  4  1
  0              9  1  4  *  7  5  3  5
                 6  2  5  9  X  4  4  4
TRS-80           5  9  9  3  4  8  8  1
  0              3  7  6  2  4  5  1  8
                 8  8  6  4  6  9  1  3

                 Which Direction for X?
```

Table 1: *Starting position for Treasure Search. The human player moves the "X" one square at a time and attempts to collect as many big numbers as possible. The computer moves the "*" on alternate turns with the same objective. The first player to accumulate one hundred points wins.*

Table 1 depicts the playing board as it might appear at the start of the game. The human player has the token designated as "X" and always moves first. Move selection is made by pressing one of the four arrow keys (←, →, ↑, ↓) on the computer keyboard. The program I will present is written for the Radio Shack TRS-80 computer in Level II BASIC.

The Treasure Search Game

The specific numbers that appear in table 1 are set randomly at the beginning of each game; therefore, a new playing field is present for each and every game. The strategy for each player is to find a pathway in which he can collect large numbers for himself and at the same time deny large numbers to his opponent. The game was originally planned for young children. I have subsequently found that it is fun for children of all ages.

To begin my presentation, I will provide a listing of the computer instructions for creating the playing field and accepting moves from the human player. Subsequently, I will present the algorithm for selecting moves for the machine and then discuss enhancements that substantially increase the efficiency of the search.

The Program

The initial statements in this program are very similar to those at the beginning of its two predecessors. Certain housekeeping functions are required, such as setting aside memory for string storage, clearing the video display, telling the machine to treat all variables as integers, resetting the "seed" for the random-number generator, and initializing important variables:

```
100 CLEAR 100: CLS: DEFINT A-Z: RANDOM:
    SH = 0: ST = 0
```

(Several versions of this program are given in the body of the text and in listings 1 thru 3.) The variables SH and ST represent the cumulative score for the human and the TRS-80, respectively.

Our next objective is to solicit the human player's name so that we can communicate with him in a civilized manner:

```
110 PRINT@463, "PLEASE ENTER YOUR NAME";:
    INPUT N$
```

The next step is to create several arrays that will be needed by the program. Two arrays are needed for remembering move directions (A and D), one is needed to provide an internal representation of the playing field (B), and several more are used by the tree search: M stores the move that is being considered at each level of the look-ahead tree; E stores the evaluation score for each of those moves; Q keeps track of which moves have been considered at each level of the tree; V keeps track of the best pathway value for each level of the tree; Z

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remembers a "killer" move for each level of the tree (this is explained later in this article); and PV is used to remember the principal variation that is selected by the tree search. The lines we will need are:

```
120 DIM A(8), B(99), D(4), E(12), M(12)
130 DIM PV(12,12), Q(12), V(12), Z(12)
```

The array representing the playing field, B, is treated as a 10-by-10 grid with the first row having indices of 0 to 9, the second row, 10 to 19, the third row 20 to 29, etc. With this organization, the "squares" adjacent to any position are always separated by a constant value. The square to the right is always the current square plus 1. The square to the left is always the current square minus 1. To go up, add 10; to go down, subtract 10. For move generation, we create an array with the following coefficients:

```
140 D(1) = -10: D(2) = -1: D(3) = 1: D(4) = 10
```

We will use a special feature of the TRS-80's architecture to produce moves for the human player. A special array is needed to take advantage of the fact that the keyboard is memory-mapped.

```
150 A(1) = 10: A(2) = -10: A(4) = -1:
    A(8) = 1: CLS
```

Since our program is designed for children of all ages, we will let the human player adjust the playing strength of the machine. Young children can play against a weak opponent. Older children can select a more competitive opponent.

```
160 PRINT@461, "TRS-80 PLAYING STRENGTH
    (1 TO 5)";:INPUT Y
```

The larger the number, the deeper we will have the machine search.

The variable DM is used to set the maximum depth of the look-ahead search. It is defined as twice the value Y minus 1. This will produce searches of one ply, three plies, five plies, seven plies, and nine plies for playing-strength settings from 1 to 5. A five-ply search involves three moves for the machine and two for the human opponent. *[A ply is a move by either opponent; the combination of one move by both sides is called a play or a turn; thus two plies equal one move. . .* **GW***]* It is also necessary to create the array that provides an internal representation of the playing field. This is done by assigning a digit from 1 to 9 to each of the squares in the playing area:

```
170 DM = 2*Y: FOR I = 11 TO 88:
    B(I) = RND(9): NEXT I
```

The squares that surround the grid are used to designate the edge of the board and are set to a value of 99 for this purpose:

```
180 FOR I = 0 TO 10: B(I) = 99: NEXT I:
    FOR I = 89 TO 99: B(I) = 99: NEXT I
190 FOR I = 19 TO 79 STEP 10: B(I) = 99:
    B(I + 1) = 99: NEXT I
```

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The playing field also needs to be presented on the video display, along with a title for the game:

```
220 CLS: FOR I = 11 TO 88: IF B(I) = 99 THEN 240
230 X$ = RIGHT$ (STR$ (B(I),1): GOSUB 1000
240 NEXT I: PRINT@22, "TREASURE SEARCH";Y;
```

The subroutine starting at line 1000 computes a location on the video screen (R = row; C = column) and prints a character there:

```
1000 R = INT (I/10): C = I-10*R:
     K = 141 + (8-R)*64+C*4
1010 PRINT@K, X$;: RETURN
```

Our next objective is to enhance our video display by printing the names of the contestants on the left-hand side of the screen where the score will be recorded. We also need to put each player's piece on the playing field and to define several useful variables. Y$ is a string variable of twelve blank spaces. Z$ is similar except it represents thirty-two blank spaces. These two variables will be used when we wish to erase part of the video display. The variable T represents the position (row-column) of the computer piece, and H represents the position of the human piece:

```
250 PRINT@256, N$;: PRINT@448, "TRS-80";:
     Y$ = STRING$ (12, " ")
260 T = 54: T$ = "*": H = 45:
     H$ = "X": Z$ = STRING$ (32, " ")
270 I = T: X$ = T$: GOSUB 1000:
     B(T) = 99: B(H) = 99
280 I = H: X$ = H$: GOSUB 1000: GOTO 300
```

The position where each player's piece is located is not available for a move, so those positions in the B array are temporarily set to the value 99.

Now we are ready to create the module that solicits the human's move. First we will start with a message to present when the requested move is not legal. This can occur if the human attempts to move off the playing field or to a position occupied by the machine's playing piece:

```
290 PRINT@788, "ILLEGAL MOVE, TRY AGAIN";:
     FOR I=1 TO 999: NEXT I
```

In most situations, line 290 will not be executed. Instead, the message will usually be a request for the human player's move:

```
300 PRINT@788,Z$;:
     PRINT@788, "WHICH DIRECTION FOR X";
```

The machine waits for the human's response by doing a rapid cycle from the beginning to the middle of line 310. When a keyboard response occurs, the machine checks a special location in memory that keeps track of the arrow keys and determines which bit has been set by the keypress:

```
310 IF INKEY$ = "" THEN 310 ELSE R = PEEK(16444)
```

The player's response is then processed to determine the

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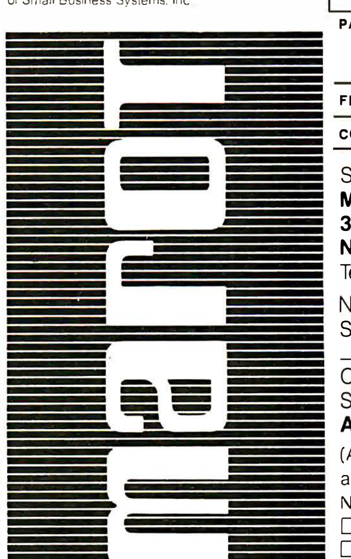
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new square (J) for his piece.

A test is also made to make sure that the new square is on the playing field and not currently occupied by the machine's piece:

```
320 R = INT(R/8): J = H+A(R)
330 IF B(J) = 99 THEN 290 ELSE PRINT@788, Z$;
```

If the move is legal, the necessary changes are made to the video display and to the internal representation of the board. In addition, the player's score is modified approximately and a check is made to determine if the game is over:

```
360 I = H: B(I) = 0: X$ = "−":
    GOSUB 1000: SH = SH+B(J)
370 H = J: B(H) = 99: I = H: X$ = H$:
    GOSUB 1000
380 PRINT@321, SH;: IF SH > 99 THEN 930
```

Move-Selection Strategy

This completes the module for soliciting and processing the move selected by the human player. We can see that Treasure Search is much easier to program than more familiar games such as chess or checkers. We are now ready to address the major focus of this article, namely, move selection by the machine. As a first approximation, I will present a relatively simplistic strategy and then subsequently will consider more sophisticated approaches.

The following initial strategy surveys the playing field in each of the four directions from the current position (T) of the machine's playing piece and selects as the best move (BM) the square which has the largest value (BV):

```
530 BV = −1: I = 0
540 I = I + 1: J = T +D(I): IF B(J) = 99 THEN 560
550 IF B(J) > BV THEN BM = J: BV = B(J)
560 IF I < 4 THEN 540
```

This is equivalent to a look-ahead search of one ply. Once a move has been selected, it is then necessary to make that move on the video display and to make the appropriate changes in the internal representation of the playing field. In addition, the score for the machine needs to be modified and a check needs to be made to determine if the game is over:

```
800 I = T: B(I) = 0: X$ = "−":
    GOSUB 1000: PRINT@179, Y$;
810 T = BM: ST = ST+B(T): B(T) = 99:
    I = T: X$ = T$
820 GOSUB 1000: PRINT@513, ST;:
    IF ST < 100 THEN 300
```

To complete the program, we need two messages to signal the end of the game:

```
910 PRINT@915,
    "THANK YOU FOR A PLEASANT GAME";
920 GOTO 920
930 PRINT@917,
    "CONGRATULATIONS, YOU WIN";: GOTO 920
1000 R = INT(I/10): C=I−10*R:
     K = 141+(8 − R)*64+C*4
1010 PRINT @ K, X$;: RETURN
```

[Please note that this simple version of the game is not the version given in listing 1. To acquire this version, type in all the BASIC lines presented so far in the text. . . ***GW****]*

Implementing α-β Techniques

If you run this program on a TRS-80, it will play a legal game, but it will not be particularly challenging. Your children will probably enjoy playing it because they will beat it most of the time. A one-ply look-ahead does not produce brilliant play. To make the machine more intelligent, we need to add the α-β minimax algorithm. To do this, we will substitute the following code for lines 530 to 560:

```
510 DT = DM
520 L = 1: SC = 0: S = −1
530 V(0) = −99: V(1) = −99: M(0) = T:
    M(1) = H
```

The maximum depth of the search, DT, is set to the value DM which was calculated at line 170. Next, we initialize several key variables. The depth of the search (L) starts with a value of 1. The variable that remembers the cumulative difference between the changes in the players' scores (SC) is set to zero. The variable that keeps track of which player has the move (S) is set to a −1.

The array that retains the best values obtained so far at each level of the tree is initialized at a −99 for index values of 0 and 1. The array that keeps track of the move (M) currently being considered at each level of the tree is set to the value T (the location of the machine's piece) for the index value of 0 and to H (the location of the human's piece) for the index value of 1.

The first move considered in the look-ahead process will be for the machine. The value of L at the base of the tree will be 2. You may think this a bit curious, but it is a useful strategy since we will want to refer to V(L − 2) and M(L − 2) at several points in the search process.

To begin the main loop of the tree search, we increase the depth (L) by 1 and then initialize the variable Q (an index for the moves that have already been considered at this level of the tree), the variable S (an index indicating whose turn it is to move), and the variable V (the value for the best move found so far at this level of the tree):

```
540 L = L + 1: Q(L) = 0: S = −S: V(L) = V(L −2)
```

The next step is to increment the Q index so that the machine can consider the next move option at this level of the tree. If we have exhausted all of the move options at this level, it is time to branch to a special section of code that instructs the machine to back up one level in the tree:

```
580 Q(L) = Q(L) + 1: IF Q(L) > 4 THEN 760
```

If the move options at this level have not been exhausted, the machine is instructed to generate the location (J) of a square to which the player can consider moving:

```
590 J = M(L − 2) + D(Q(L))
```

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*Execution time ratio, Eratosthenes Sieve

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Making Moves

Move generation is quite simple because M(L−2) always represents the current location of the piece of the player whose turn it is to move and D(Q(L)) represents one of the four directions in which a move can potentially be made. I say potentially because the new location could be off the playing field or could already be occupied by the opponent's piece. Our next statement checks for this:

```
600 IF B(J) = 99 THEN 580 ELSE M(L) = J: E(L) = B(J)
```

If the move is legal, the new location is recorded as the current move at this level in array M, and the digit at this location is recorded as the current value at this level in array E. In addition, the internal representation of the playing field, B, is modified to reflect this move, and the variable SC is altered to keep track of the relative points accumulated by each player:

```
610 B(J) = 99: B(M(L - 2)) = 0: SC = SC + S * E(L)
```

In order to provide a visible record of the machine's "thought" process, the machine is instructed to print the move location (J), the cumulative change in the score at this point (SC), and the best value so far at this level, V(L), in the empty area on the right side of the video display. The machine also checks to see if the current depth is the maximum possible depth. If not, it branches to line 540 which starts the main loop again by going one level higher in the tree:

```
620 PRINT@179 + 64*L, J; SC; V(L); " ";:
    IF L < DT THEN 540
```

If the search is at the maximum depth (ie: L = DT), then the machine records the current value of SC as a potential new best value:

```
670 V(L + 1) = -S * SC
```

The next step is to reverse the move we just made. When a new move is made, the board representation is updated at line 610. When the move is taken back at line 680, we refer to the process of "downdating" the board:

```
680 B(M(L)) = E(L): B(M(L - 2)) = 99:
    SC = SC - S * E(L)
```

Negamax

To determine whether the value recorded at line 670 is better than the current value at this level, we employ the *negamax* procedure (see reference 1). This is equivalent to the minimax procedure except that its implementation requires fewer programming steps. Rather than minimizing and maximizing at every other level, the negamax approach always maximizes the results at a given level, but it reverses the arithmetic signs at every other level to produce the identical result as the minimax procedure. (You may recognize the similarity between this approach and the use of the logical NOR operation in circuit design. Two levels of NOR logic are equivalent to a level of ANDs followed by a level of ORs.) The following line implements the negamax calculations:

```
700 IF V(L) < -V(L + 1) THEN
    V(L) = -V(L + 1) ELSE 580
```

If the new value is worse than or equal to the current value, the machine branches to line 580 and considers another move at this level. If the new value is better than the current value, the machine continues to the next statement:

```
740 IF L = 2 THEN BM = M(L):
    PRINT@180, BM; V(2);
```

If the search process is at the base of the tree (L = 2), then the new best move is recorded for later use and an announcement of our new find is printed on the video display. This includes both the new location, BM, and the net difference in the score produced by the anticipated sequence of moves, V(2)

Evaluating for Cutoff

At line 700, the minimax rule was applied to select the best option for the player with the move. The next consideration is whether the current move will produce an α-β cutoff. The logic for this decision is based on the idea that the opponent may already have a move at this level in the tree that guarantees him a value that is at least as

good as the one we are considering in the current branch.

This procedure is easy to implement but not particularly easy to understand. The general idea was explained by an example by W D Maurer in an earlier issue of this magazine (see reference 2), and a detailed exposition is provided by Knuth and Moore (reference 1). For our purposes, the job is accomplished by a single statement:

```
750 IF V(L) < -V(L - 1) THEN 580
```

If the condition specified in line 750 is satisfied, then a cutoff is not called for, and the process branches to line 580, where the next move option is considered at this level. If the condition in line 750 is not satisfied, the process continues to line 760, which instructs the machine to back up one level in the tree:

```
760 L = L - 1: S = -S: PRINT@243 + 64 * L, Y$;:
    IF L > 1 THEN 680
```

The backup procedure includes decreasing the value of L by 1, changing the index that indicates which player has the move, erasing the move information printed on the right side of the video display, and branching to line 680 to execute the downdate instructions for the new value of L. If the value of L decreases to 1, all options at the base of the tree have been examined and the search is completed. In this case, the machine drops to line 800 and makes the move which has been stored by variable BM.

It is important to note that the jump to line 680 for downdating is followed by execution of the minimax test (line 700) for a new best move at the new value of L; sometimes the program proceeds again to line 750, where another cutoff may occur. Note, also, that line 760 can be entered from two different locations. In addition to dropping through from line 750, the machine can be directed to line 760 from line 580 as a result of exhausting all possible move options at a given level. The α-β test at line 750 provides a means for terminating the search at a node before all of the options have been analyzed.

The version of Treasure Search just completed is given in listing 1.

Listing 1: *Listing for the game of Treasure Search, written for the TRS-80 using Level II BASIC. This game, in its various versions, illustrates the usefulness of alpha-beta pruning when searching a tree for the best strategy in a two-player game. The game, as written here, plays an unmodified alpha-beta strategy against a human player. See listings 2 and 3 for additions that cause the computer to play more rapidly.*

```
100 CLEAR 100: CLS: DEFINT A-Z: RANDOM: SH = 0:
    ST = 0
110 PRINT@463, "PLEASE ENTER YOUR NAME";: INPUT N$
120 DIM A(8), B(99), D(4), E(12), M(12)
130 DIM PV(12,12), Q(12), V(12), Z(12)
140 D(1) = -10: D(2) = -1: D(3) = 1: D(4) = 10
150 A(1) = 10: A(2) = -10: A(4) = -1: A(8) = 1: CLS
160 PRINT@461, "TRS-80 PLAYING STRENGTH (1 TO 5)";:
    INPUT Y
170 DM = 2*Y: FOR I = 11 TO 88: B(I) = RND(9): NEXT I
180 FOR I = 0 TO 10: B(I) = 99: NEXT I: FOR I = 89 TO 99:
    B(I) = 99: NEXT I
190 FOR I = 19 TO 79 STEP 10: B(I) = 99: B(I + 1) = 99:
    NEXT I
220 CLS: FOR I = 11 TO 88: IF B(I) = 99 THEN 240
230 X$ = RIGHT$ (STR$ (B(I),1): GOSUB 1000
240 NEXT I: PRINT@22, "TREASURE SEARCH"; Y:
250 PRINT@256, N$;: PRINT@448, "TRS-80";:
    Y$ = STRING$ (12, " ")
260 T = 54: T$ = "*": H = 45: H$ = "X":
    Z$ = STRING$ (32, " ")
270 I = T: X$ = T$: GOSUB 1000: B(T) = 99: B(H) = 99
280 I = H: X$ = H$: GOSUB 1000: GOTO 300
290 PRINT@788, "ILLEGAL MOVE, TRY AGAIN";:
    FOR I = 1 TO 999: NEXT I
300 PRINT@788, Z$;: PRINT@788, "WHICH DIRECTION FOR
    X";
310 IF INKEY$ = "" THEN 310 ELSE R = PEEK(16444)
320 R = INT(R/8): J = H + A(R)
330 IF B(J) = 99 THEN 290 ELSE PRINT@788, Z$;
360 I = H: B(I) = 0: X$ = "-": GOSUB 1000: SH = SH + B(J)
370 H = J: B(H) = 99: I = H: X$ = H$: GOSUB 1000
380 PRINT@321, SH;: IF SH > 99 THEN 930
510 DT = DM
520 L = 1: SC = 0: S = -1
530 V(0) = -99: V(1) = -99: M(0) = T: M(1) = H
540 L = L + 1: Q(L) = 0: S = -S: V(L) = V(L - 2)
580 Q(L) = Q(L) + 1: IF Q(L) > 4 THEN 760
590 J = M(L - 2) + D(Q(L))
600 IF B(J) = 99 THEN 580 ELSE M(L) = J: E(L) = B(J)
610 B(J) = 99: B(M(L - 2)) = 0: SC = SC + S * E(L)
620 PRINT@179 + 64 * L, J; SC; V(L); " ";: IF L < DT THEN
    540
670 V(L + 1) = -S * SC
680 B(M(L)) = E(L): B(M(L - 2)) = 99: SC = SC - S * E(L)
700 IF V(L) < -V(L + 1) THEN V(L) = -V(L + 1) ELSE 580
740 IF L = 2 THEN BM = M(L): PRINT@180, BM; V(2);
750 IF V(L) < -V(L - 1) THEN 580
760 L = L - 1: S = -S: PRINT@243 + 64 * L, Y$;: IF L > 1
    THEN 680
800 I = T: B(I) = 0: X$ = "-": GOSUB 1000: PRINT@179, Y$;
810 T = BM: ST = ST + B(T): B(T) = 99: I = T: X$ = T$
820 GOSUB 1000: PRINT@513, ST;: IF ST < 100 THEN 300
910 PRINT@915, "THANK YOU FOR A PLEASANT GAME";
920 GOTO 920
930 PRINT@917, "CONGRATULATIONS, YOU WIN";:
    GOTO 920
1000 R = INT (I/10): C = I - 10 * R: K = 141 + (8 - R) * 64 +
     C * 4
1010 PRINT@K, X$;: RETURN
```

Traditional Techniques

This completes the α-β minimax module. You may be surprised that this algorithm can be presented in only a few lines of BASIC. The simplicity of the presentation is possible because we used the negamax procedure and because Treasure Search is a simple game. It is very straightforward in terms of move generation (line 590), move evaluation (line 600), and the ease of updating (line 610) and downdating (line 680) the internal representation of the playing field. This simplicity also means that the algorithm will execute fairly rapidly, and thus a search of nontrivial depth can be completed in a reasonable amount of time.

The algorithm that I have presented for the α-β minimax procedure is quite different from the one that appears in most textbooks. Traditionally, the algorithm generates all of the moves at each node and then orders them using a plausibility routine before proceeding to the next deeper level of the tree. This approach is based on

Listing 2: *To implement the killer heuristic, these lines are to be added to listing 1, replacing line 590 of listing 1 and inserting lines 550, 560, and 710.*

```
550 J = Z(L): I = 0
560 I = I + 1: IF J = M(L - 2) + D(I) THEN 600 ELSE IF I < 4
    THEN 560
590 J = M(L - 2) + D(Q(L)): IF J = Z(L) THEN 580
710 IF L > 2 THEN Z(L) = M(L)
```



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the well-known finding that the efficiency of the α-β method is increased greatly when the strongest moves for each player are examined first at each level of the tree. The disadvantage of generating, ordering, and storing all of the moves at each level is that most of them will never be examined if an α-β cutoff occurs. If a cutoff can be produced by some other means, a great deal of time and memory can be saved by ignoring most of the moves at each node and omitting the ordering process.

The obvious question is, of course, how can we have our cake and eat it too? The competition among chess programmers over the last decade has led to some useful discoveries that are relevant to this problem. We will consider two of these discoveries that are especially effective in increasing the efficiency of the α-β minimax procedure. The first is the *killer heuristic* and the second is the *iterative search.*

The Killer Heuristic

The killer heuristic is a simple, yet powerful, idea that greatly improves move ordering. Instead of trying to order moves on the basis of a special plausibility analysis, the killer procedure simply remembers moves that were effective in the past. That is, information generated as a byproduct of the regular tree search is remembered; and it is applied later on in the search when a similar situation is encountered. In our implementation, we will remember the move that was judged most recently to be the best by the minimax rule at each level of the tree; each time we visit a new node in the tree, this move will be tried first.

To implement this idea, a few additions and modifications are necessary (see listing 2). When the tree search moves to a higher level, the first move examined should be the killer for that level (lines 550 and 560 of listing 2).

First, the appropriate move is read from the Z array, then a check is made to make sure the move is legal. If the killer does not produce an immediate cutoff, the search process will revert back to the normal procedure of examining each of the possible options. This process is controlled at lines 580 and 590.

We need to modify line 590 of listing 1 to make sure that a move is not examined twice (first as the killer and then as a regular option).

The final step in implementing the killer heuristic is to provide a means for remembering the move which is currently most effective in terms of the minimax strategy at each level of the look-ahead tree. This is accomplished by recording the current move each time the search process finds that it is the best one so far; this is done at line 700 of listing 1.

If the process is at the base of the tree (L = 2), then the move need not be recorded since the killer strategy does not apply at this level. It is too late to define a move that should be searched first at the base of the tree. By not altering the killer at L = 2, we make sure that the move examined initially will be searched only once even if it turns out not to be the one eventually chosen.

The killer heuristic is a very powerful addition to the α-β minimax algorithm. It requires only a small change in the algorithm, involves a negligible amount of time in terms of code execution, and often results in a decrease of 50% or more in the number of nodes actually visited in the search tree. At the deeper levels of the tree, it accomplishes essentially the same function as plausibility ordering, but does it much more efficiently.

The killer heuristic does not provide a means for ordering the moves when the machine is constructing the initial "limb" of the look-ahead tree. Because the search is a depth-first search, the process begins by selecting a sequence of moves that starts at the base node and goes to the maximum depth. The α-β cutoffs are most effective if this initial limb contains the strongest moves at each node for each player. This first stage of the search can be very time-consuming if the moves that are initially examined are eventually discarded for better ones. Because the killer heuristic employs strong moves only after they have been discovered by the regular search process, it is not helpful in structuring the initial "limb" of the look-ahead process.

The Iterative Technique

A different technique has proven its effectiveness for this purpose. This procedure is the *iterative tree search.* Its effectiveness for increasing the efficiency of the α-β minimax procedure was discovered serendipitously. At Northwestern University, for example, the Slate-Atkin chess-programming team was concerned about time control in move selection. Occasionally, in a complex position, their chess program would conduct its regular look-ahead search and would not complete the task in the amount of time anticipated. In several instances, the search would require four to five times as long as anticipated. This was a serious problem because chess tournaments are conducted under strict time allowances. If a program takes too much time for move selection during the early stages of the game, very little time will be available when it is needed during the latter part of the contest.

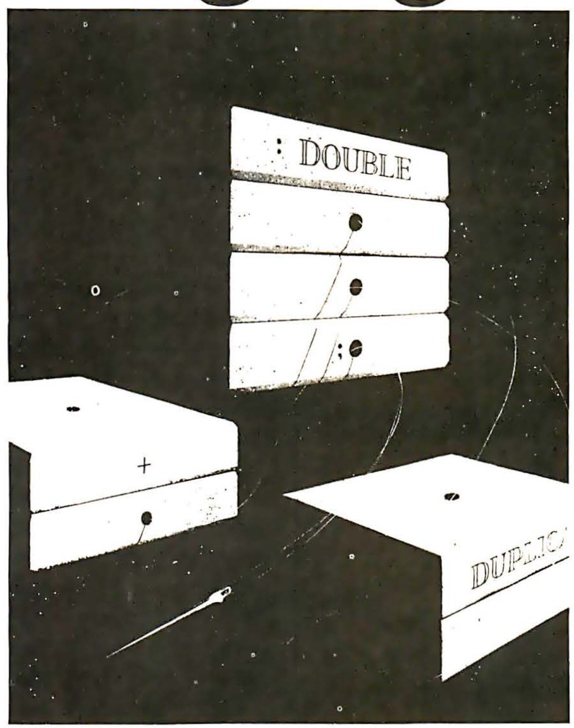
To cope with this problem, Slate and Atkin implemented an iterative procedure whereby the search is conducted in stages. At first, a complete two-ply search is conducted, then a three-ply search, then a four-ply search, etc, until a search of the desired depth is reached. The advantage of this procedure for time control is that a search can be aborted at any time and the machine can fall back upon the move selected by the immediately preceding search of one less ply in depth. It is possible to use information gained in the early, shallow searches to help structure (ie: order) the deeper searches.

Interestingly enough, Slate and Atkin discovered that this ordering information caused an increase in the efficiency of the deeper searches which more than made up for the time spent conducting the shallow searches. They also found that the beneficial effect of the iterations increases as the depth of search increases.

The iterative search is much easier to implement than you might think. The key idea for enhancing the efficiency of the α-β search is that the best sequence of moves (as judged by the minimax strategy) from a shallow search can be used to order the initial moves in the deeper search which follows. It is necessary to develop and record the *principal variation* for each of the searches.

This means that, instead of remembering just the best move at the base of the tree, the machine needs to record the best moves for each side at every level of the tree. Thus, it predicts the initial move, the best reply, the best counter-reply, etc. This principal variation is then used for selecting the initial limb for the next deeper search in

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Listing 3: *Additions to listing 1 to implement an iterative tree search algorithm. These lines are to be added to the combination of listings 1 and 2.*

```
500 FOR I = 4 TO DM: Z(I - 2) = PV(2,I): NEXT I
510 IF PV(2,3) = H THEN DT = DM ELSE DT = 2
720 I = L: PV(L,I) = M(L): IF L = DT THEN 740
730 I = I + 1: PV(L,I) = PV(L + 1,I): IF I < DT THEN 730
780 IF DT = DM THEN 800
790 FOR I = 2 TO DT: Z(I) = PV(2,I): NEXT I: DT = DT + 2:
    GOTO 520
```

the iteration. In our present algorithm, we employ this strategy by placing the principal variation from the previous search in the killer array at the start of each iteration.

The first requirement is the development and storage of the principal variation. This is fairly difficult to explain but not very difficult to implement (see lines 720 and 730 of listing 3). Once we have a principal variation, we then modify the initial preparation for the look-ahead search (see lines 500 and 510 of listing 3).

This accomplishes two important things. At line 500, the killer array receives the moves for each side that were ascertained to be best on the move calculation from the previous turn (not the previous iteration of this turn, but rather the last time the machine made a move). The index I-2 is used because the first two moves anticipated by that variation (one for the machine and one for the opponent) have already been played.

Line 510 checks to see if the opponent actually made the anticipated move. If so, an iterative search is unnecessary since the principal variation from the previous move calculation provides the same ordering information as would be obtained by the iterations. The search depth, DT, is therefore set to the maximum depth, DM. If the opponent does not make the anticipated move, an iterative search is required and therefore the search depth, DT, is set at the minimum value. Note that DT = 2 calls for a one-ply search.

When a search has been completed, it is necessary to determine if the maximum depth has been reached or whether another iteration is required. If the latter case holds true, the principal variation from the most recent iteration is stored in the killer array and the search depth is increased. In our present implementation, each iteration is two plies deeper than its predecessor. Lines 780 and 790 of listing 3 accomplish this task.

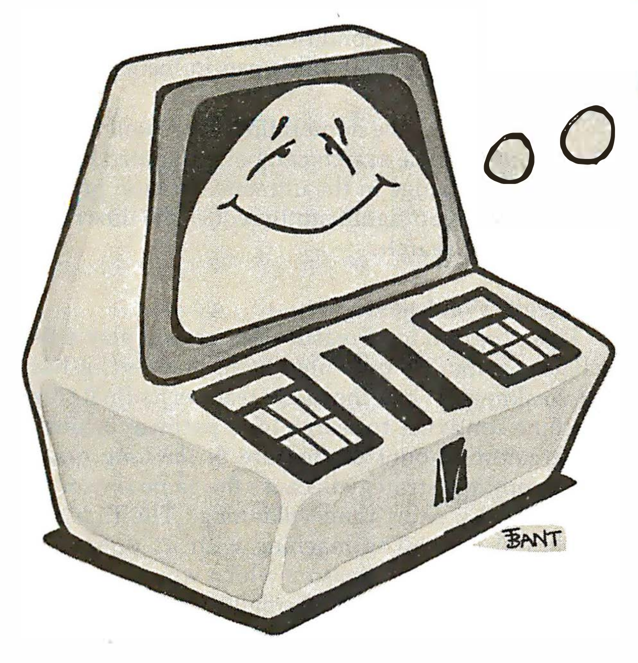
Analysis of Modifications

With these additions, the program will select a move in the Treasure Search game by using an iterative α-β minimax procedure enhanced by the killer heuristic. To demonstrate the power of this modified algorithm, I have made some sample runs which count the number of nodes visited in the look-ahead tree in an actual game with and without the various modifications. These results are very informative.

The program was examined in four variations: minimax, α-β minimax, α-β minimax with the killer heuristic, and iterative α-β minimax with the killer heuristic. The version involving the minimax strategy without α-β is produced simply by replacing line 750 with:

```
750 GOTO 580
```

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This eliminates all of the α-β cutoffs.

To insure comparability of our results, an initial game configuration (digit assignment) was constructed and placed in an array such that each game started with the playing field depicted in table 1. In addition, the same series of moves was made by the human opponent in each game. Each version of the program calculated a move for the machine's first four times to play. In each case, the search depth was set for a seven-ply search. The number of nodes in each of the look-ahead trees is presented in table 2. The node count for the iterative search is the sum across all iterations.

An analysis of these results demonstrates the powerful effect of the α-β procedure. By using the IF statement at line 750 in the α-β versions, the search effort is reduced dramatically. In our example with a seven-ply search and with four options at each node, the α-β modification reduces the node count by a factor of about 10. Since there is an approximate linear relationship between the number of nodes in the tree and computation time, the α-β procedure selects a move in one-tenth the time of the full minimax search. Since the two procedures always select the same move, this enhancement in speed comes at essentially no extra cost.

The results in table 2 indicate that the killer heuristic is also a powerful addition to the α-β algorithm. In our example, the node count was reduced by 30% to 50% by simply remembering moves that had proved themselves effective at an earlier stage in the search.

This modification also provides substantial benefits at minimal extra cost in terms of processing time and memory requirement. The empirical analysis presented in table 2 also demonstrates the beneficial effects of the iterative procedure. The number of nodes generated in the calculation for the first move was reduced by almost 25% despite the fact that searches of one ply, three plies, and five plies were conducted prior to the seven-ply search.

In the calculations for moves 2, 3, and 4, the prior principal variation correctly predicted the human's move so that the machine dispensed with the iterations because it already had the ordering information they would have produced. The results presented in table 2 clearly indicate that the iterative procedure enhances the efficiency of the search process.

	Number of Nodes in the Look-ahead Tree			
	First Move	Second Move	Third Move	Fourth Move
Minimax	13157	18456	20029	17609
α-β Minimax	1965	1650	1641	1794
α-β Minimax with Killer Heuristic	969	1023	926	830
Iterative α-β Minimax with Killer Heuristic	753	571	675	363

Table 2: *An empirical analysis of the minimax algorithm and enhancements as applied to the Treasure Search game. Each version of the program conducted a seven-ply look-ahead search.*

Improvements

A comparison of the full minimax procedure as it was employed in the early 1950s with the modern, enhanced α-β procedure indicates a truly dramatic increase in search efficiency. The full minimax procedure averaged approximately 17,000 nodes for the first four move calculations. The modern algorithm as presented in this article averaged approximately 600 nodes for these same four calculations. This difference is large enough to convert an impractical but elegant idea into a powerful programming tool. I should also point out that the effectiveness of these procedures would be even more notable if we had examined a game like chess with more than thirty options at each node instead of a simple game with only four options at each node.

There is an additional way to increase the efficiency of the α-β search. In the present program, the evaluations of the terminal positions are based on a cumulative process in which the treasures collected at each node in the tree are added or subtracted to a running total. As the search process nears the maximum depth of the tree, it is possible to set boundary conditions (ie: a window) that determine whether the final value can influence the selection process.

In many cases, the nonterminal score will be sufficiently deviant that the search can be terminated prematurely wthout any change in the ultimate decision process. This enhancement can significantly reduce the time required to complete the search.

Strategic Weakness

This program for Treasure Search will play a fairly intelligent game. As presented here, however, it has a major weakness. When the game reaches its final stages, the machine continues to search for a pathway which gives it the greatest amount of treasure *in the long run.* This is not an optimal strategy because the game is won or lost at this stage by short-range planning. The first player to reach 100 wins. The machine with its present strategy may pass up a large treasure which would provide an immediate win in favor of a smaller one which ultimately leads to a rich lode. This could throw away an easy win.

Serious players may wish to introduce a special set of instructions for the endgame to correct for this weakness. The machine's game can also be strengthened by converting the program to assembly language. The deeper the look-ahead search, the greater the apparent intelligence of the machine. Conversion to assembly language will permit the program to search six plies deeper without increasing move-selecting time.

This article should provide useful information to anyone who wishes to write a game program which employs the α-β minimax procedure.■

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The Automatic Apartment

Dear Steve,

I would like to congratulate you on your remote-control article using the BSR X-10 ("Computerize a Home," January 1980 BYTE, page 28). I have built a unit, and it is now so much a part of my life that I take it for granted. It wakes me up, controls the lights, and guards the apartment in conjunction with a simple burgler alarm.

I have envisioned a system of lighting control that would illuminate any room that I enter, while darkening the one I just left.

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:

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Glastonbury CT 06033

If you are a subscriber to The Source, send your questions by electronic mail or chat with Steve (TCE317) directly. Due to the high volume of inquiries, personal replies cannot be given. Be sure to include "Ask BYTE" in the address.

For this system to work, it must keep track of the number of people in the apartment (if there are more than one), and it must be able to sense their motion from room to room. Thus, if one person is in the living room, and he goes to the kitchen, the kitchen light should come on, while the living room light should go off. If there were more than one person in the living room, the light should remain on until the last person has left. Of course, manual control should be available, and the system should be able to recognize any sensing errors it may make, and reset itself accordingly.

Obviously, I need a doorway sensor that will detect a person passing through, and also detect the direction he is going. Would you suggest ultrasonic sensors, or would infrared optical sensors be more practical? Could you provide some circuit ideas to help me along?

Jim Porter

I am always glad to hear from someone who takes computer control seriously. Having a computer and automating your apartment makes being "gadget happy" sound almost respectable. In any case, I am familiar with your problem, and I'll try to offer a few circuits that might help.

When I first got involved with security systems, I did a lot of investigation on motion detectors, ultrasonics, and infrared systems. Very few companies offer automatic systems that count people and control lights in rooms. This should give you some indication of what you are getting yourself into.

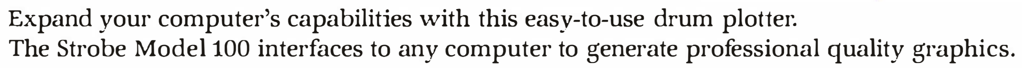
Two possible methods that come to mind are detecting the motion of people within a room or counting them as they enter and exit.

Motion detectors usually incorporate one of three techniques: infrared, ultrasonic, and microwave. The infrared types are the cheapest. They rely upon changes in ambient light,

Text continued on page 270

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1b

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IC1	LM1812		5, 10, 15	12
IC2	NE555	8	1	
IC3	7404	14	7	

Figure 1: *Ultrasonic transmitters. The circuit of 1a has a usable range of about twenty feet. The circuit of figure 1b is more appropriate for greater distances. Both circuits transmit continuously at 23 kHz.*

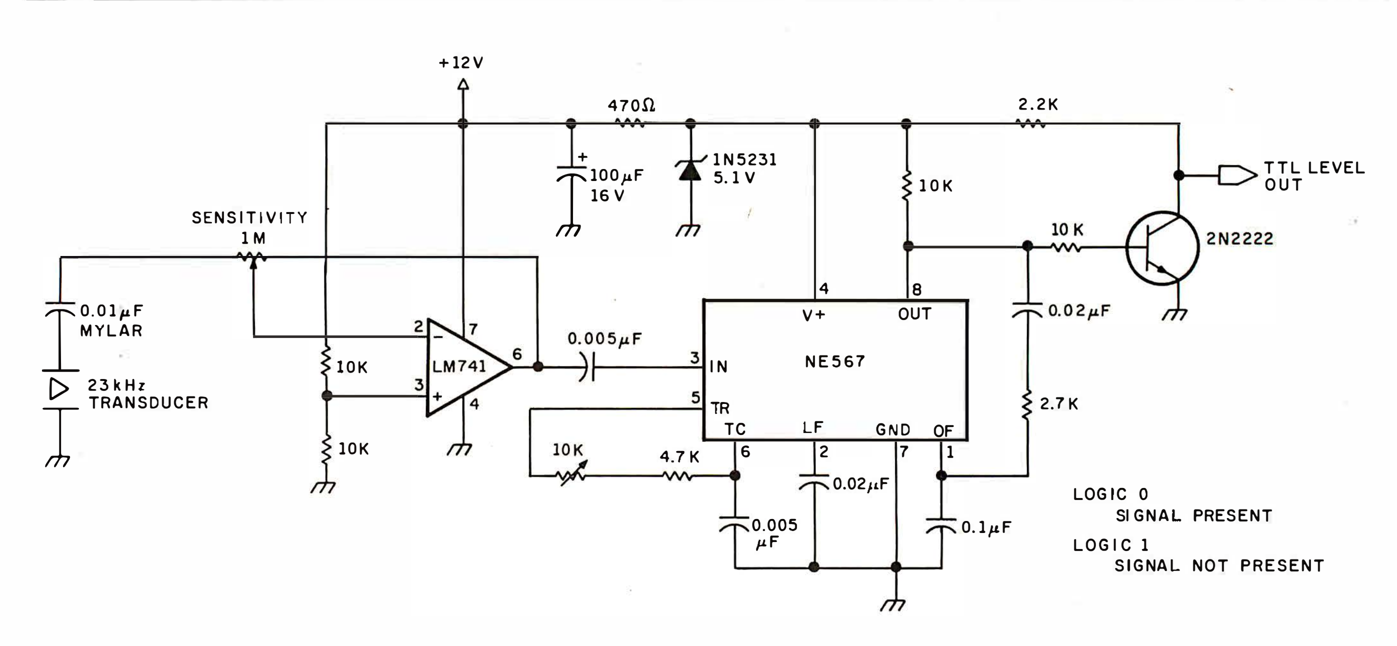


Figure 2: *Ultrasonic receiver. This simple receiver has TTL-compatible outputs, and it will work with either transmitter in figure 1.*

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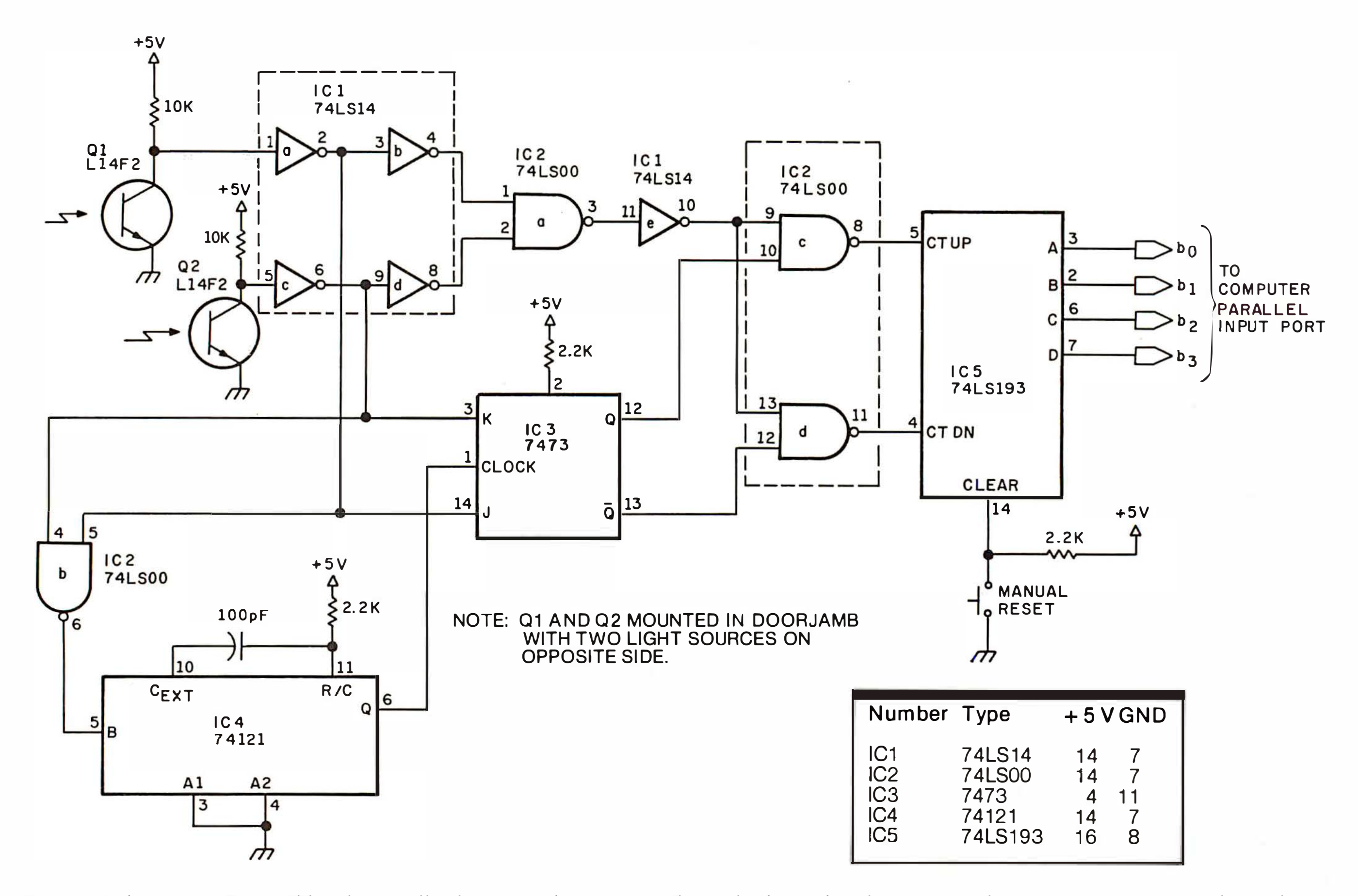
1124

Text continued from page 266:
and the latest designs incorporate an active photosensitive integrated circuit. In fact, Delco Electronics (7 Oakland St, POB 2, Amesbury MA 01913) was offering an under-$30 kit a while back. In your application, with lights flashing on and off this may not be a reliable approach.

There are many ultrasonic systems on the market, and they range in price from $50 to $100. My only criticism of them is that they are prone to false alarms and you may find that the harmonics interfere with the BSR system. If you'd like to try placing one across a doorway or diagonally across a room, you could try the circuits shown in figures 1 and 2. These units operate at 23 kHz. Depending upon the sensitivity setting, they will detect most anything passing through the beam. For small rooms, you won't need much power, so the circuit of figure 1a should suffice. If you need a range of greater than twenty feet, use the higher-power version shown in figure 1b. The receiver for either circuit is shown in figure 2. By the way, the output is TTL (transistor-transistor logic)-compatible. Normally the signal will be a logic 0 (ie: nothing interrupting the beam between the transmitter and receiver); the signal will go to a logic 1 only when someone walks into the room.

The most effective system for detecting motion uses microwave radiation—similar to police radar and operating on the same X-band frequency. In my experience, these are the best by far. They are relatively false-alarm free and very sensitive. I have them installed throughout my home, and I have found their reliability to be exceptional. Unfortunately, they are expensive (in the range of $150 to $400 for domestic installations). A good unit is the Midex 55 made by Solfan (665 Clyde Ave, Mountain View CA 94043). Solfan's more expensive units have contact-closure outputs which would work well in your application.

The final solution to your problem might be to build a people counter. The circuit in figure 3 (sent to me by William Curlew) might be exactly what you need. It consists of two photodetectors (and two separate light sources) mounted in the doorjamb. Normally the light beam is uninterrupted and the output of the photodetectors is low. As long as there is light on both sensors, the output of IC2b is low. As someone starts through the doorway, one of the sensors goes high, clocking the JK flip-flop into one of two direction states. When the person fully enters the doorway, blocking both the sensors, a trigger pulse is generated and sent to gates 2c and 2d. Depending upon the state of the flip-flop, the clock pulse will be directed to either the count-up or count-down line of the 4-bit up/down counter, IC5. The counter will increment as people walk into the room and decrement they walk out. A manual reset is provided to start things out correctly. When the 4 outputs are tied to a parallel input port, your computer can read it as often as necessary to determine how many people are left in the room. Since the counting is done in hardware, timing is not critical. It will accommodate only fifteen people in its present form, so don't have too many guests at your parties. Finally, for absolute certainty, you may want to use it with the ultrasonic circuits previously discussed.
Steve



Number	Type	+5 V	GND
IC1	74LS14	14	7
IC2	74LS00	14	7
IC3	7473	4	11
IC4	74121	14	7
IC5	74LS193	16	8

Figure 3: *This circuit is capable of optically detecting the passage of people through a doorway and maintaining a count of people in a room. The photo-transistors sense motion through the doorway and cause the count stored in IC5 (a 4-bit binary counter) to either be incremented or decremented, depending upon the direction of passage.*

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Circle 172 on inquiry card.





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Remote Control in Europe

Dear Steve,

Please tell me if the X-10 remote-control system by BSR could be operated on 220 V 50 Hz in Europe. I see from the schematic diagrams and various pictures it is designed to work on 110 V 60 Hz. Do they have a 220 V system? If not, is there any way I could adapt the system to work on a 220 V system.

Please tell me where I can buy the set (ie: common console, cordless controller, appliance module, lamp module, in-wall switch module) using an American Express card; maybe from Sears as you said in your article. If so, please let me know the address of Sears; for that matter, any reliable dealer who accepts American Express. I'll be grateful for the two answers. Next time you are in Europe drop in and see us. We have a wood stove too, and I hope to connect it to the central heating system.

Rangith Amitirigala
Brugg, Switzerland

Up to this point the X-10 system has been available only in the American version (115 VAC 60 Hz). The custom LSI (large-scale integration) device used in the American units, surprisingly enough, can work on either 50 or 60 Hz. The polarity set on pin 13 of the command-console integrated circuit selects either of the two operating frequencies. These consoles cannot, however, be easily converted from 115 V to 220 V operation without considerable component changes.

A call to BSR (USA) Ltd in New Jersey produced some fruitful answers to your question. Even though BSR is working on a European version of the X-10, another company has just announced availability of a 220 V 50 Hz unit. I suggest that you contact this firm for price and delivery. The source is: Busch-Jaeger Elektro GmbH, 5880 Ludenscheid, Freisenberg, Post Fach 1280, West Germany (BRD).

As for Sears Roebuck and Company, it is my understanding that the firm accepts only its own credit card. Rather than worry about which stores will accept your credit card, you may find it easier to go your local bank (in Switzerland) and arrange for a letter of credit or bank draft when ordering from an American company.

Steve

Operational Amplifiers

I have been using the AD284J isolation operational-amplifier system that you described in "Mind Over Matter" (June 1979 BYTE, page 49) as an EKG (electrocardiogram) monitor, in conjunction with a surplus chart recorder. Can you recommend some books that will help me to learn more about operational amplifiers?

Matsutoshi Uchiyma
Tokyo, Japan

I am glad you are gaining experience with the circuit. As far as expanding your mind a little, I suggest the following books:

- Operational Amplifiers—Design and Applications, *Jerald G Graeme, Gene E Tobey, and Lawrence P Huelsman, McGraw-Hill Book Company, New York NY 1971.*
- Applications of Operational Amplifiers—Third Generation Techniques, *Jerald G Graeme, McGraw-Hill Book Company, New York NY 1973.*
- Handbook of Operational Amplifier Circuit Design, *David F Stout and Milton Kaufman, McGraw-Hill Book Company, New York NY, 1976.*

I hope these help.
Steve

Beyond "Cyclops"

Dear Steve,

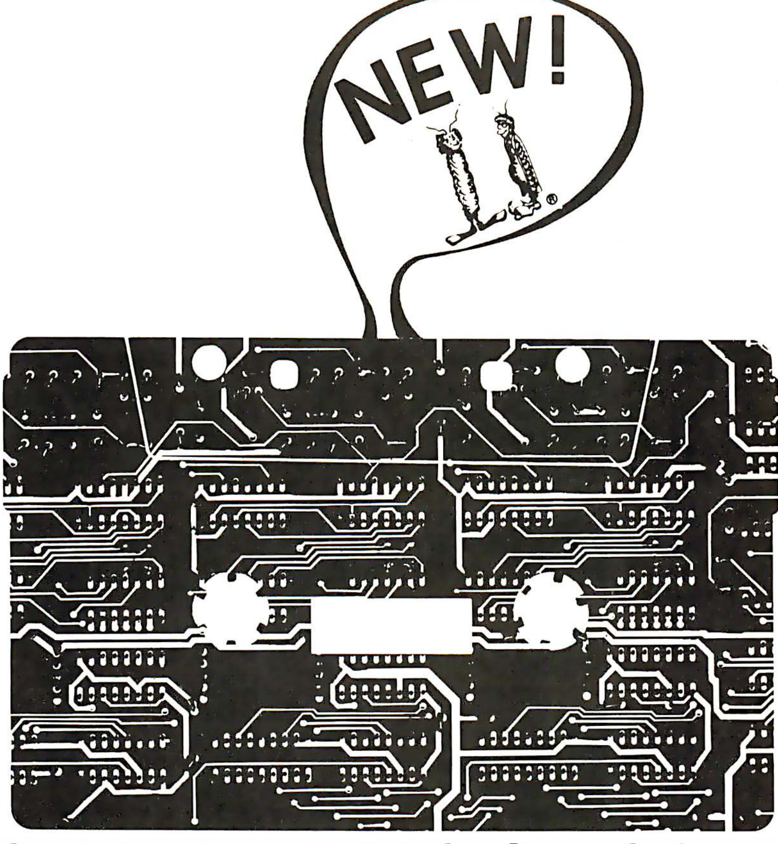
I consider your series of articles the best collection of homebrew-type construction ideas and projects available to the personal-computer experimenter. Your article "Self-Refreshing LED Graphics Display" (October 1979 BYTE, page 58) has prompted me to write you.

I'd like to propose a project to you. I understand that a construction project called "Cyclops" appeared in *Popular Electronics* that actually used a dynamic-memory integrated circuit to act as a "pseudo-image sensor." Can this unique idea be extended to larger-area memory devices? The 4 K-byte circuit would make a nice 64-by-64 element array.

Jesse Newton

Thanks for the pat on the back. Sometimes late at night I need it.

I remember that article



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Circle 174 on inquiry card.

well, and I have wanted to try exactly what you suggest. I've waited because I want fairly high resolution. Perhaps with the new 32 K and 64 K bit devices I will try it. Give me a little time.

The real problem I have is that there are so many good article ideas. I still want to put a computer in a car, do something with solar heat, remote control, and robotics. As long as you haven't been dissatisfied with everything so far, I trust that I'll find something interesting in the meantime.
Steve

Across-the-Sea File

Dear Steve,

I read with great interest your article "Computerize a Home" (January 1980 BYTE, page 28), and I am interested in the BSR X-10 system.

I contacted the Commercial Section of the US Embassy here and also my employer's purchasing agent in New York, but neither could find me the address of the BSR Company. I would appreciate it if you could tell me the manufacturer's address.

Thank you.
Z Lapidot
Rehovot, Israel

The address for BSR is: BSR (USA) Ltd, Rt 303, Blauvelt NY 10913, telephone: (914) 358-6060. There are many stocking distributors for its products including: The Software Exchange, 6 South St, Milford NH 03055.

BSR is an English company, and there may be outlets closer to you than those listed here.
Steve

Point-to-Point

Dear Steve,

My compliments for a fine set of articles over the years. Only recently have I had the time to try some of the projects you write about. I am planning to build the DVM (digital voltmeter) from your article in the January 1978 BYTE ("Add More Zing to the Cocktail," page 37).

I have contacted the printed-circuit board manufacturer that you mentioned in your article, but it no longer has boards available for that particular project. I do have all the components, and would like to avoid the tedium of hand-wiring the project. Do you have any boards available for a reasonable price?

I plan to use this circuit as part of a solar-energy-collector measurement system (among other things). I'm also trying to work out a method to manage energy consumption around the house.
Frank J Pakulski

A lot of people have built and are using the DVM interface you mention. (Please note a typographical error in table 1 of that article. On IC1 pin 24 is +5 V, pin 13 is ground, and pin 12 is −5 V.) I'm sorry that the company that once sold the components no longer supplies them. I have noticed that companies such as Jameco sell the MC14433 DVM chip, but not the printed-circuit board.

Recently, I have been arranging for boards and kits on some of my articles. This time the sources are more closely regulated and the boards and parts will be available far into the future.
Steve

In-Depth Information Center

Dear Steve,

I would like you to recommend some texts that would introduce me to computer hardware, from basic switching theory through the actual architecture of a computer. I'm tired of superficial prose intended for the general consumer. I need some more in-depth information that is found only in engineering texts. You know, something that presents the computer from the electronics engineer's point of view in a well-structured manner. What do you suggest? As a postscript, I would also like to learn about Pascal.
Daniel R Shook

You ask an extremely difficult question. I have talked to other computer enthusiasts and it seems that (given the wide variety of texts and computer books being published) no two can agree on what is best. I have felt that there is a void in this area, and, as a matter of fact, I have just written a book on building a Z80 computer system from scratch. It's above the introductory level, but not just for engineers—similar to my articles. It should be published in early 1981.

In the meantime, I suggest you join the McGraw-Hill Electronic & Control Engineers book club. Many of its monthly selections are introductory texts written for engineers.

A good book on Pascal is Pascal User Manual and Report—Second Edition, *by Jensen and Wirth from Springer-Verlag.*
Steve ■

Circle 175 on inquiry card.

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THE COMPUTER, in our solitaire scenario, plays Wellington while you play Napoleon. Two levels of play are provided by making the entry of Prussian reinforcements variable. This makes the need for French military decisiveness and devastating execution even more critical.

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*Creative Computing, Aug. 1980.
**Popular Mechanics, Aug. 1980.

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Circle 176 on inquiry card.

Text continued from page 82:
subroutine name, length, and the subroutine instructions. Thus, our load-subroutine primitive can be represented as:

$$\text{LSUB N,L,}D_0..D_{n-1}$$

where:

N = subroutine name or number
L = subroutine length
D_i = subroutine instructions

For example, the primitive:

$$\text{LSUB CLIP,5,}D_0..D_4$$

loads a subroutine named CLIP with the given five instructions.

In order to maintain a sense of symmetry with these primitives, we need to include a primitive to read back a given subroutine. Although this feature does not affect the displayed image, it does aid the host in debugging and keeping track of the current status of the display. Thus, we require a read-subroutine primitive, which can be represented as:

RSUB N

where:

N = subroutine name or number

For example, the primitive:

RSUB CLIP

reads the instructions of the subroutine CLIP and presents the data to the host.

We have also assumed the existence of a programmable symbol generator. In order to support this feature, there is the need for some method of loading the generator. We either need to load an entirely new font definition in the symbol generator or alter only certain symbols: thus we must provide the option of loading the entire set or only one element. We can define each symbol by providing data which represents either the vectors that make up the symbol or by defining a bit pattern that forms the image of the symbol. In either case, our load-symbol primitive can be represented as:

$$\text{LSYM M,(A,)}D_0..D_n$$

where:

M = mode (*A*ll symbols or a *S*ingle symbol)
A = symbol code (optional: for single symbol only)
D_i = data mask defining the symbol

For example, the primitive:

$$\text{LSYM S,80,}D_0..$$

loads the symbol numbered 80 with the given data mask.

Symmetrically, we must include a primitive to read back the data describing a single or all symbols. This feature is necessary to be able to produce hard copies of the displayed image. The host must know, if an image is to be plotted, how the current font is defined. We use the same justification as above to support the option of reading all or only selected symbols. Mnemonically, our read-symbol primitive can be represented as:

RSYM M(,A)

where:

M = mode (*A*ll symbols or a *S*ingle symbol)
A = symbol code (optional: for single symbol only)

For example, the primitive:

RSYM A

reads back the entire font definition to the host.

In order to fully support a requirement for hard copy, two final primitives have to be provided. First, since we have assumed the existence of a color-look-up table, we must have some manner of reading back the values of the table to the host. Otherwise, the host would have to keep track of the current color definitions. This primitive thus reduces the host's bookkeeping and allows information on the actual displayed colors to be read back. For the same reasons as we described for the load-color-memory primitive, we must support the same options of reading back either the entire table, one entire parameter, or all parameters for one color code. Mnemonically, we can represent our read-color-memory primitive as:

RCRAM R,M(,A)

where:

R = reference (*I*ntensity, *H*ue, or *S*aturation color memory, or *A*ll)
M = mode (*S*ingle address or *A*ll addresses)
A = address (optional: for single address only)

For example, the primitive:

RCRAM I,A

reads back the contents of the entire intensity color memory.

Finally, we must be able to read back values of the pixel data itself. This feature is necessary not only for the support of hard copy, but allows the host to interrogate the display to read back the values of pixels at specified points in the image. We use the same justification as for the load-pixel primitive to support the various options of reference (full-frame, viewport, or X,Y). Mnemonically, our read-pixel primitive can be represented as:

RPIX R

where:

R = reference (*F*ull-frame, *V*iewport, or *X,Y*)

For example, the primitive:

RPIX F

reads back the contents of the entire display-frame buffer.

This completes our set of graphics

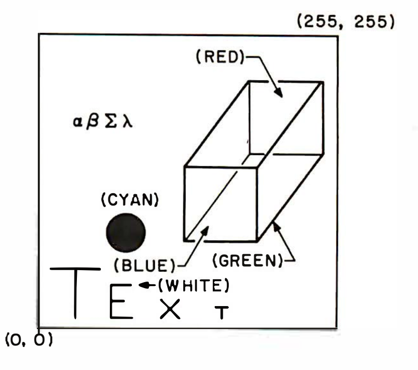


Figure 5: *A sample of the images produced by Micrograph using the primitives of listing 1.*



primitives for a color raster-scan display. The graphics primitives are summarized in table 2. Note that this list does not include primitive instructions for operations such as circle or arc generation. Such features can be generated by existing primitives (using the vector-drawing primitive). Furthermore, circle and arc primitives are difficult to generalize and cannot easily support any more complex curves: their utility is therefore very limited for the cost of their implementation in terms of support hardware and display-processor software. Furthermore, features such as transformations are not included at this level since they presuppose a definite image structure that cannot be known by the display processor. Other

Text continued on page 292

Listing 1: *This arrangement of primitives developed for Micrograph was used to produce the images in figure 5.*

```
MOV   20,10                      (T)
VEC   SHORT,REL,WHITE,20,30
MOV   5,30                       (T)
VEC   SHORT,REL,WHITE,25,30
MOV   30,10                      (E)
VEC   SHORT,REL,WHITE,30,20
MOV   30,10                      (E)
VEC   SHORT,REL,WHITE,40,10
MOV   30,15                      (E)
VEC   SHORT,REL,WHITE,40,15
MOV   30,20                      (E)
VEC   SHORT,REL,WHITE,40,20
MOV   50,10                      (X)
VEC   SHORT,REL,WHITE,60,20
MOV   50,20                      (X)
VEC   SHORT,REL,WHITE,60,10
MOV   70,10                      (T)
VEC   SHORT,REL,WHITE,70,15
MOV   65,15                      (T)
VEC   SHORT,REL,WHITE,75,15
LREG  VPORT,30,45,40,60        (rectangle
      around circle)
LPIX  VPORT,CYAN0..CYAN149
LREG  VPORT,120,60,200,120 (part of
      cube)
LPIX  VPORT,BLUE
LREG  VPORT,170,170,250,230 (part of
      cube)
LPIX  VPORT,RED
MOV   120,60
VEC   SHORT,REL,GREEN,170,170 (part
      of cube)
MOV   200,120
VEC   SHORT,REL,GREEN,250,230 (part
      of cube)
MOV   200,60
VEC   SHORT,REL,GREEN,250,230 (part
      of cube)
MOV   120,120
VEC   SHORT,REL,GREEN,170,250 (part
      of cube)
MOV   20,200
SYM   4,α,β,Σ,λ          (from user-defined
      font)
```

5 types of primitives, 37 instructions, 300 parameters



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This General Ledger system performs the essential functions of dual entry bookkeeping and matches revenues and expenses:
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LEDGER 1 - builds and maintains the CHART OF ACCOUNTS file. This file contains both current and accumulated totals for each account.
LEDGER 2 - builds and updates the JOURNAL TRANSACTION file.
LEDGER 3 - lists both the the JOURNAL file and the CHART OF ACCOUNTS.
LEDGER 4 - computes the TRIAL BALANCE and executes POSTING of journal transactions into the CHART OF ACCOUNTS. An AUDIT TRIAL of all transaction is output.
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LEDGER 6 - produces the BALANCE SHEET. Assets, liabilities and owners' equities are shown by account and by totals. **$140.00**

MICROPAY

An Accounts Payable system, MICROPAY includes the following program & functions:
PAY 1 - initializes both Transaction and Master files, then begins the Accounts Payable process by inputting and adding records in the Transaction file.
PAY 2 - allows for changes and deletions of Transaction and Master records.
PAY 3 - reports outstanding Accounts Payables in four categories; under 30 days, 31-60 days, 61-90 days, and over 90 days.
PAY 4 - reports all outstanding Accounts Payables for a single customer or for all customers, and computes Cash Requirements.
PAY 5 - reports all outstanding Accounts Payables for a single date or for a range of dates and computes the Cash Requirements.
PAY 6 - lists both the Transactions and Master files.
PAY 7 - prints checks and accumulates and journalizes Accounts Payables. This program simultaneously creates entries for the MICROLEDGER file. **$140.00**

MICROREC

An Accounts Receivable system, MICROREC includes the following programs and functions:
REC 1 - initializes Accounts Receivable files, adds A/R record and prints invoices.
REC 2 - accepts receipt of customer payments and changes or deletions of A/R Transaction or Master file records.
REC 3 - reports outstanding Accounts Receivables in four categories; under 30 days, 31-60 days, 61-90days, and over 90 days.
REC 4 - reports all outstanding Accounts Receivables for a single customer, or for all customers and computes Cash Projections.
REC 5 - produces reports for all outstanding Accounts Receivables for a single date or for a range of dates and computes Cash projections.
REC 6 - lists Transaction and Master files and accumulates and journalizes Accounts Receivables, creating JOURNAL entries which communicate with the MICROLEDGER JOURNAL file. **$140.00**

MICROINV

This Inventory Control system presents a general method of Inventory Control and produces several important reports. Its program includes:
INV 1 - initializes Transaction and Master files and adds and updates Transaction and Master records.
INV 2 - handles inventory issued or received, creating inventory records. This program also accumulates and journalizes transactions, producing JOURNAL entries which communicate with the MICROLEDGER file.
INV 3 - lists both Transaction and Master files.
INV 4 - produces the STOCK STATUS REPORT, showing the standard inventory stock data and stock valuation, and the ABC ANALYSIS breaking down the inventory into groups by frequency of usage.
INV 5 - gives a JOB COST REPORT/MATERIALS, showing allocation of materials used year-to-date by each job or work code. (This is complemented by the Job Cost Report/Personnel in the MICROPERS program.)
INV 6 - computes and provides the E.O.Q. (Economic Order Quantities) **$140.00**

MICROPERS

This is a Payroll/Personnel program whose functions include:
PERS 1 - initializes the Master file and allows for entry and updates of Master records.
PERS 2 - initializes the Payroll file and allows for entry and updates of payroll records.
PERS 3 - lists an Employee Master Record or the entire Employee Master file; lists a single Payroll Record or the entire Payroll file.
PERS 4 - computes Payroll and prints the PAYROLL REGISTER. Prints PAYCHECKS and creates JOURNAL entries to be fed into the MICROLEDGER JOURNAL file.
PERS 5 - produces the JOB COST REPORT/PERSONNEL, computes the quarterly 941 bank deposit, and the Annual W-2 run. **$140.00**

All COMPUMAX programs available in machine readable format (diskette form) for the following machines:

TRS-80™ Model I	Micropolis 1053/11
APPLE II	Microsoft under CP/M
PET	CBASIC under CP/M
	Cromemco

FROM ADVENTURE INTERNATIONAL (By Scott Adams)

† 1. **ADVENTURELAND** - You wander through an enchanted world trying to recover the 13 lost treasures. You'll encounter wild animals, magical beings, and many other perils and puzzles. Can you rescue the Blue Ox from the quicksand? Or find your way out of the maze of pits? Happy Adventuring .....

† 2. **PIRATE'S ADVENTURE** - "Yo ho ho and a bottle of rum" You'll meet up with the pirate and his daffy bird along with many strange sights as you attempt to go from your London flat to Treasure Island. Can you recover Long John Silver's lost treasures? Happy Sailing, matey .....

3. **MISSION IMPOSSIBLE ADVENTURE** - Good morning, your mission is to... and so it starts. Will you be able to complete your mission in time? Or is the world's first automated nuclear reactor doomed? This one's well named. It's hard, there is no magic, but plenty of suspense. Good luck .....

4. **VOODOO CASTLE** - Count Cristo has had a fiendish curse put on him by his enemies. There he lies, with you his only hope. Will you be able to rescue him or is he forever doomed? Beware the Voodoo Man .....

★ *All orders processed within 24-Hours*
★ *30-Day money back guarantee on all Software (less a $3 penalty for handling)*

5. **THE COUNT** - You wake up in a large brass bed in a castle somewhere in Transylvani. Who are you, what are you doing here, and WHY did the postman deliver a bottle of blood? You'll love this Adventure, in fact, you might say it's Love at First Byte .....

6. **STRANGE ODYSSEY** - Marooned at the edge of the galaxy, you've stumbled on the ruins of an ancient alien civilization complete with fabulous treasures and unearthly technologies. Can you collect the treasures and return or will you end up marooned forever? .....

7. **MYSTERY FUN HOUSE** - Can you find your way completely through the strangest Fun House in existence, or will you always be kicked out when the park closes? ...

8. **PYRAMID OF DOOM** - An Egyptian Treasure Hunt leads you into the dark recesses of a recently uncovered Pyramid. Will you recover all the treasures or more likely will you join its denizens for that long eternal sleep? .....

9. **GHOST TOWN** - Explore a deserted western mining town in search of 13 treasures From rattlesnakes to runaway horses, this Adventure's got them all! Just remember, Pardner, they don't call them Ghost Towns for nothin'. (Also includes new bonus scoring system!) .... **$14.95 Per Adventure**

* **Note:** Apple requires 24K and has no lower case.
† Recommended for the novice adventurer, with many built-in HELPS!

FROM PERSONAL SOFTWARE INC.

VISICALC **$150.00**

Take virtually any problem you would explore using calculator, pen, and paper, working in rows and columns. Apply VisiCalc and you'll see why every reviewer of this product has said the same thing: VisiCalc is the most useful, most important program yet developed for personal computing.

With VisiCalc, you work with an electronic worksheet of up to 63 columns and 254 rows. At the juncture of any column and row you can type in words and numbers. VisiCalc automatically performs all arithmetic functions, net present value, and transcendental functions - instantly!

CCA DATA MANAGEMENT SYSTEM $74.95

DMS Features:
File Creaton and Maintenance:
- Fields may be alphanumeric, numeric, integer, floating point, or fixed decimal with commas.
- Fields may be COMPUTED FIELDS. DMS will compute any field within a record, using constants or other fields in the same record. Functions include add, subtract, multiply, divide, and raise exponential powers.
- Records are easily located, using the SCAN feature. SCAN for records with a field over, below, or between a range of values.
- Records are easily added and updated. DMS "prompts" you with questions.
- Multi-diskette capabilities for larger files - up to 85,000 characters per file!
- Sort the records into almost any order, using up to 10 fields as "keys". So you can sort for customer numbers; within zip code, for instance.
- Delete records, "compact" files, and backup files on data diskettes easily.

Report Features:
- Print reports with records in any order.
- Select fields to be printed.
- Print mailing labels.
- Numeric totals and subtotals can be specified when a value in an unrelated field in the same record changes. For example, sort, subtotal, and print according to department, or month, or customer number, or model number.

GUARANTEED PROFIT **91%** WINS PLACES SHOWS **32%** AVERAGE PROFIT AT ALL TRACKS-1978

THE HORSE SELECTOR II (FLATS) (By Dr. Hal Davis) $50.00

New simplified version of the original Horse Selector. The first Horse Selection System to actually calculate the estimated odds of each horse.
HIGHER PROFITS (OVER 100%) POSSIBLE THROUGH SELECTIVE BETTING ON:
- Rates each horse in 10 seconds.
- Easy to follow rules.
- Can be used with any Apple II Computer.
- 100% money back guarantee (returned for any reason).
- Uses 4 factors (speed rating, track variant, distance of the present race, distance of the last race)
- Using the above factors, the Horse Selector calculates the estimated odds. BET on horses whose actual payoff (from the Tote Board or Morning Lines) is higher than payoff based on estimated odds.
- Using the above factors, the Horse Selector calculates the estimated odds. BET on any selected horse with an estimated payoff (based on Tote Board or Morning Lines) higher than calculated payoff (based on Horse Selector II).
- Source listing for the TRS-80™, TI-59, HP-67, HP-41, Apple and BASIC Computers.
- No computer or calculator necessary (although a calculator would be helpful for the simple division used to calculate estimated odds)

FREE Dutching Tables allows betting on 2 or more horses with a guaranteed profit.



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NEW TOLL-FREE ORDER LINE
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Circle 179 on inquiry card.

Listing 2: *The first third of the firmware for Micrograph control, written for the Z80 microprocessor used in the prototype. The remaining portions of the firmware will be included in the next two issues of BYTE, along with hardware construction details (Part 2, December 1980 BYTE), and software (Part 3, January 1981 BYTE).*

```
              *H MICROGRAPH FIRMWARE SYSTEM 1
              *P 62
              ;
              ; MICROGRAPH 1.0 ****************************************
              ;
              ; DEVELOPED BY GRADY BOOCH
              ;
              ; MICROGRAPH IS A FIRMWARE CONTROLLED MICROPROCESSOR
              ; BASED COLOR GRAPHICS DISPLAY SYSTEM, BUILT AS A
              ; SINGLE BOARD DISPLAY PROCESSOR, WHICH INTERFACES
              ; TO A STANDARD UNMODIFIED COLOR TELEVISION. THE USER
              ; SEES MICROGRAPH AS A 256 X 256 PIXEL SYSTEM, 8 BITS
              ; PER PIXEL. THIS SYSTEM IS MAPPED TO AN EQUAL OR LOWER
              ; RESOLUTION DISPLAY. GRAPHICS PRIMITIVES ARE AVAILABLE
              ; TO ALLOW THE USER TO CREATE GRAPHICS DISPLAYS.
              ; MICROGRAPH INTERFACES TO A HOST COMPUTER VIA THREE
              ; 8 BIT I/O PORTS. FURTHER INFORMATION IS AVAILABLE
              ; IN THE MICROGRAPH REFERENCE MANUAL.
              ;
0000                  ORG   0                 ;START AT ADDRESS 0
0000  F3      MICROG: DI                      ;DISABLE INTERRUPTS
0001  C38F00          JP    MAIN              ;JUMP TO MAIN
              ;
              ;*****************************************************
              ;GLOBAL DEFINITIONS, CONSTANTS AND STRUCTURES**********
              ;*****************************************************
              ;
              ; STRUCTURES ******************************************
              ;
              ; STRUCTURES PROVIDES STORAGE FOR ALL FIRMWARE
              ; VARIABLES AND STRUCTURES. DEFAULT VALUES ARE PROVIDED
              ; IN THIS SECTION, WHICH IS STORED IN EPROM. STRUCTURES
              ; ARE MOVED TO RAM DURING INITIALIZATION, AND REFERENCED
              ; VIA THE OFFSETS DESCRIBED IN DEFINITIONS. NOTE THAT
              ; THE FIRST SEVERAL BYTES OF RAM ARE RESERVED FOR THE
              ; GRAPHICS AND MICROPROCESSOR STACKS.
              ;
              ESTRUCT:EQU  $                  ;START OF STRUCTURES
              EGDR:   EQU  $                  ;GRAPHICS DISPLAY REG
0004  00      EGDR0:  DEFB 0                  ;X
0005  00      EGDR1:  DEFB 0                  ;Y
0006  FF      EGDR2:  DEFB 255                ;PRIMARY COLOR
0007  00      EGDR3:  DEFB 0                  ;SECONDARY COLOR
0008  00      EGDR4:  DEFB 0                  ;FRAME COUNT
0009  02      EGDR5:  DEFB 00000010B          ;VECTOR MODE
000A  00      EGDR6:  DEFB 0                  ;VIEWPORT 0 LEFT X
000B  00      EGDR7:  DEFB 0                  ;VIEWPORT 0 LEFT Y
000C  FF      EGDR8:  DEFB 255                ;VIEWPORT 0 RIGHT X
000D  FF      EGDR9:  DEFB 255                ;VIEWPORT 0 RIGHT Y
000E  00      EGDR10: DEFB 0                  ;VIEWPORT 1 LEFT X
000F  00      EGDR11: DEFB 0                  ;VIEWPORT 1 LEFT Y
0010  FF      EGDR12: DEFB 255                ;VIEWPORT 1 RIGHT X
0011  FF      EGDR13: DEFB 255                ;VIEWPORT 1 RIGHT Y
0012  08      EGDR14: DEFB 00001000B          ;DISPLAY FORMAT
0013  80      EGDR15: DEFB 10000000B          ;STATUS
              ESLINK: EQU  $                  ;GRAPHICS SUB LINKAGE
0014  A50A    EL00:   DEFW USER               ;SUBROUTINE 00
0016  A50A    EL01:   DEFW USER               ;SUBROUTINE 01
0018  A50A    EL02:   DEFW USER               ;SUBROUTINE 02
001A  A50A    EL03:   DEFW USER               ;SUBROUTINE 03
001C  A50A    EL04:   DEFW USER               ;SUBROUTINE 04
001E  A50A    EL05:   DEFW USER               ;SUBROUTINE 05
0020  A50A    EL06:   DEFW USER               ;SUBROUTINE 06
0022  A50A    EL07:   DEFW USER               ;SUBROUTINE 07
0024  A308    EL10:   DEFW GUSER              ;SUBROUTINE 10
0026  A308    EL11:   DEFW GUSER              ;SUBROUTINE 11
0028  A308    EL12:   DEFW GUSER              ;SUBROUTINE 12
002A  A308    EL13:   DEFW GUSER              ;SUBROUTINE 13
002C  A308    EL14:   DEFW GUSER              ;SUBROUTINE 14
002E  A308    EL15:   DEFW GUSER              ;SUBROUTINE 15
0030  A308    EL16:   DEFW GUSER              ;SUBROUTINE 16
0032  A308    EL17:   DEFW GUSER              ;SUBROUTINE 17
              ESLONG: EQU  $                  ;GRAPHICS SUB LENGTH
0034  01      ES00:   DEFB 1                  ;SUBROUTINE 00
0035  01      ES01:   DEFB 1                  ;SUBROUTINE 01
0036  01      ES02:   DEFB 1                  ;SUBROUTINE 02
0037  01      ES03:   DEFB 1                  ;SUBROUTINE 03
0038  01      ES04:   DEFB 1                  ;SUBROUTINE 04
0039  01      ES05:   DEFB 1                  ;SUBROUTINE 05
003A  01      ES06:   DEFB 1                  ;SUBROUTINE 06
003B  01      ES07:   DEFB 1                  ;SUBROUTINE 07
003C  01      ES10:   DEFB 1                  ;SUBROUTINE 10
003D  01      ES11:   DEFB 1                  ;SUBROUTINE 11
003E  01      ES12:   DEFB 1                  ;SUBROUTINE 12
003F  01      ES13:   DEFB 1                  ;SUBROUTINE 13
0040  01      ES14:   DEFB 1                  ;SUBROUTINE 14
0041  01      ES15:   DEFB 1                  ;SUBROUTINE 15
0042  01      ES16:   DEFB 1                  ;SUBROUTINE 16
0043  01      ES17:   DEFB 1                  ;SUBROUTINE 17
0044  00      ESPTR:  DEFB 0                  ;GRAPHICS SUB POINTER
0045  00      ESOFF:  DEFB 0                  ;GRAPHICS SUB OFFSET
0046  00      EGPC:   DEFB 0                  ;GRAPHICS STACK POINTER
0047  00      EREF:   DEFB 0                  ;CURRENT VIEWPORT REFERENCE
0048  00      EM:     DEFB 0                  ;VECTOR DRAWING TEMP
0049  00      EMM:    DEFB 0                  ;VECTOR DRAWING TEMP
004A  00      EMN:    DEFB 0                  ;VECTOR DRAWING TEMP
004B  00      ESX:    DEFB 0                  ;VECTOR DRAWING TEMP
004C  00      ESY:    DEFB 0                  ;VECTOR DRAWING TEMP
004D  00      ECOLOR: DEFB 0                  ;VECTOR COLOR STORAGE
004E  0000    EXERRT: DEFW 0                  ;ERROR SERVICE TEMP
0050  C9      ENULL:  DEFB 11001001B          ;FRAME SERVICE
              ;
              ; NON MASKABLE INTERRUPT TRAP *************************
              ;
              ; A TRAP TO THIS LOCATION IN MEMORY OCCURS UPON RECEIPT
              ; OF A NON MASKABLE INTERRUPT. THIS SECTION FORCES A
              ; JUMP TO THE ERROR SERVICE ROUTINE, XERR.
              ;
0066          NMINT:  ORG  102                ;LOCATION OF INTERRUPT
0066  1834            JR   XERR               ;JUMP TO ERROR SERVICE
              ;
              ; CONSTANTS *******************************************
              ;
              ; CONSTANTS PROVIDES STORAGE FOR ALL FIRMWARE CONSTANTS
              ; WHICH ARE STORED IN EPROM.
              ;
              CONST:  EQU  $                  ;START OF CONSTANTS
              IVECT:  EQU  $                  ;START OF INTERRUPT VEC
0068  4601    INT0:   DEFW FRAME              ; RAME SERVICE
006A  6801    INT1:   DEFW INPUT              ;INPUT SERVICE
006C  7601    INT2:   DEFW OUTPUT             ;OUTPUT SERVICE
              PENTER: EQU  $                  ;PRIMITIVE ENTRY POINTS
006E  6F02            DEFW CALLS              ;CALLS ENTRY
0070  AB02            DEFW LCRAM              ;LCRAM ENTRY
0072  1403            DEFW LPIX               ;LPIX ENTRY
0074  8703            DEFW LREG               ;LREG ENTRY
0076  9F03            DEFW LSUB               ;LSUB ENTRY
0078  CB03            DEFW LSYM               ;LSYM ENTRY
007A  FB03            DEFW MOV                ;MOV ENTRY
007C  8504            DEFW RCRAM              ;RCRAM ENTRY
007E  EE04            DEFW RETN               ;RETN ENTRY
0080  0E05            DEFW RPIX               ;RPIX ENTRY
0082  5705            DEFW RREG               ;RREG ENTRY
0084  6505            DEFW RSUB               ;RSUB ENTRY
0086  8705            DEFW RSYM               ;RSYM ENTRY
0088  BB05            DEFW SYM                ;SYM ENTRY
008A  4606            DEFW VEC                ;VEC ENTRY
008C  8807            DEFW WAIT               ;WAIT ENTRY
```

Listing 2 continued on page 282

YOUR MODEL II CAN HAVE SNAPP!

SNAPP II EXTENDED BASIC

A family of enhancements to the Model II BASIC interpreter. Part of the package originated with the best of APPARAT, INC.'s thoughts in implementing NEWDOS BASIC. The system is written entirely in machine language for SUPER FAST execution. The extensions are fully integrated into Model II BASIC, and require NO user memory, and NO user disk space. The package is made up of the following five modules, each of which may be purchased separately:

XBASIC - Six single keystroke commands to list the first, last, previous, next, or current program line, or to edit the current line. Ten single character abbreviations for frequently used commands: AUTO, CLS, DELETE, EDIT, KILL, LIST, MERGE, NEW, LLIST, and SYSTEM. $25

XREF - A powerful cross-reference facility with output to display and/or printer. Trace a variable through the code. Determine easily if a variable is in use. $40

XDUMP - Permits the programmer to display and/or print the value of any or all program variables. Identifies the variable type for all variables. Each element of any array is listed separately. $40

XRENUM - An enhanced program line renumbering facility which allows specification of an upper limit of the block of lines to be renumbered, supports relocation of renumbered blocks of code, and supports duplication of blocks of code. $40

XFIND - Permits quick and easy location of specified strings or keywords within the program text. $30

SAVE - on the purchase of the entire package. $140

CONVERT

This remarkable utility converts "V" format files (the sequential format used by the SHACKS, COBAL and BASIC Compilers) to the "F" format files (the sequential file format used by the BASIC interpreter and BASCOM), and vice versa. Without this product, programs written for the interpreter will have to be RE-KEYED to be used by the SHACKS Compiler BASIC. $75.00

SKRUNCH

A SUPER FAST TRSDOS UTILITY. Compresses your BASIC programs to an absolute minimum. Typically saves 30-40% space, even for programs without REM statements! Also results in 7-10% improvement in execution speed. $35

SBASIC — Model I and Model II

Program in a high-level, full structured BASIC! The BEST of the BASIC pre-processors. PERFORM named subroutines. CONDITIONAL case structures. WHILE loops. UNTIL loops. And much more. Forget about line numbers. Model II version is compiled, and SUPER FAST. From Ultimate Computer Systems Model I $50 Model II $75

DOSFIX



A collection of patches to TRSDOS and BASIC to enhance their usability and function includes our well-known BREAK7E patches to keep the break key from being used accidentally. FREE WITH ANY MODEL II SOFTWARE PACKAGE.

FRIEND

FOUR NEW TRSDOS COMMANDS!

SHOW — A much better multi-disk directory display. Let's you see only those files you want, and includes date of last update.

MOVE - A much better file copying command. Copy/Move whole groups of files, renaming them at the same time, if desired, with just 1 command!

ERASE - Better than KILL, better than PURGE.

PRINT - Print BASIC programs from disk, whether saved in ASCII or compressed.

All 4 DOS commands allow fast processing of one, or complete groups of files, based on generic naming and wild card specifications. Enhanced functions too numerous to fully describe here.

EXAMPLES:

SHOW PAY*/BAS*

Directory display of all '/BAS' files on all diskettes which begin with 'PAY.'

MOVE PAY*/BAS:1 TO =/OLD:3

Save current versions of payroll programs to drive 3, changing extensions to '/OLD.'

MOVE OLD*/* TO NEW =/= :1

Copy all files on drive 0 which begin with 'OLD,' regardless of extension, to drive 1, changing the first 3 letters of the filename to 'NEW,' but retaining the same file extension.

Save time!
Reduce frustration!
Eliminate ERROR 33! $75

HOSTII / TERMII

Allows 'remote control' of a Model II from another Model II, or any ASCII terminal. If terminal is a Model II, accurate screen positioning (PRINT @) is fully supported! Requires NO user memory! This system is designed to provide software support to our customer locations without ever leaving the office. $50

BUGZAP



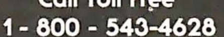
A powerful utility oriented toward the machine language programmer. Display/Modify/Print/Memory/Disk sectors. Use this to help you learn more about the internals of the Model II. $50



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(513) 891-4496

Call Toll Free



1 - 800 - 543-4628

Most products will soon be available for the Model I. CALL FOR DETAILS!

MASTER / SLAVE

This software package was designed to support the transferring of files from one Model II to another, via direct connection or modem/phone line connection. ALL kinds of files, and baud rates up to 9600 are fully supported. Transfer files in either direction, even with the SLAVE Model II UNATTENDED! $150

SPOOLER — Model I and Model II



Our workhorse! This package, available for Model I, in the TRSDOS/NEWDOS or NEWDOS 80 versions, or for the Model II, greatly enhances system performance when running typical business applications. Many applications have been benchmarked to run nearly TWICE AS FAST with the SPOOLER installed. Installs in minutes, and no changes are required to your programs. Preferred Model II versions require NO user memory. Optional features for the Model II version only: Serial printer support, and DISK SPOOLING support. The DISK SPOOLING support is particularly recommended for word processing applications. $100

SERIAL PRINTER OPTION $50
DISK SPOOLING OPTION $50

ROUTE



Causes LPRINT data to be sent to the video screen! A great help in writing and debugging programs when no printer is available, you have a slow printer, or you are just in a hurry. Can be turned on and off from within your BASIC program. Requires NO user memory. $25

SCREEN



Supports the copying of the full video screen to the printer. Can be invoked by the operator with a keystroke, or from your program with a USR call. Requires NO user memory. $25

SAVE



Retrieve the resident BASIC program following an accidental SYSTEM, or a system crash. DON'T BE WITHOUT THIS ONE. YOU NEVER KNOW WHEN YOU WILL NEED IT! $35

TERMS OF SALE:



Credit card customers, add 3% C.O.D. customers add $3. Ohio residents add 4½% sales tax. Shipments normally made the same day we receive your order.

OUR GUARANTEE:



If your diskette arrives damaged, we will replace it without charge. If you ever accidentally damage it, we will replace it for a $10 handling charge. For a period of one year, we will provide you with any enhancements or updates for a $10 handling charge. For a period of one year, if errors are discovered in the programs, they will be corrected without charge. In the event we cannot correct an error, you may return the program material for a refund.

TRS-80 is a trademark of the Radio Shack division of Tandy Corporation.
NEWDOS and NEWDOS/80 are trademarks of Apparat, Inc.

Listing 2 continued:

```
        ; DEFINITIONS ****************************************
        ;
        ; DEFINITIONS PROVIDES GLOBAL DEFINITIONS OF VARIOUS
        ; STRUCTURES AND VARIABLES.
        ;
DEFIN:  EQU     $                      ;START OF DEFIN
RESTART:EQU     0                      ;RESTART ADDRESS
PBOTTM: EQU     4096                   ;BOTTOM OF PRIVATE RAM
MSTACK: EQU     PBOTTM+63              ;BOTTOM OF MICRO STACK
GSTACK: EQU     MSTACK+64              ;BOTTOM OF GRAPH STACK
STRUCT: EQU     GSTACK+1               ;START OF STRUCTURES
RELOC:  EQU     -ESTRUCT               ;RELOCATION CONSTANT
GDR:    EQU     RELOC+EGDR             ;GRAPHICS DISPLAY REG
GDR0:   EQU     RELOC+EGDR0            ;X
GDR1:   EQU     RELOC+EGDR1            ;Y
GDR2:   EQU     RELOC+EGDR2            ;PRIMARY COLOR
GDR3:   EQU     RELOC+EGDR3            ;SECONDARY COLOR
GDR4:   EQU     RELOC+EGDR4            ;FRAME COUNT
GDR5:   EQU     RELOC+EGDR5            ;VECTOR MODE
GDR6:   EQU     RELOC+EGDR6            ;VIEWPORT 0 LEFT X
GDR7:   EQU     RELOC+EGDR7            ;VIEWPORT 0 LEFT Y
GRD8:   EQU     RELOC+EGDR8            ;VIEWPORT 0 RIGHT X
GDR9:   EQU     RELOC+EGDR9            ;VIEWPORT 0 RIGHT Y
GDR10:  EQU     RELOC+EGDR10           ;VIEWPORT 1 LEFT X
GDR11:  EQU     RELOC+EGDR11           ;VIEWPORT 1 LEFT Y
GDR12:  EQU     RELOC+EGDR12           ;VIEWPORT 1 RIGHT X
GDR13:  EQU     RELOC+EGDR13           ;VIEWPORT 1 RIGHT Y
GDR14:  EQU     RELOC+EGDR14           ;DISPLAY FORMAT
GDR15:  EQU     RELOC+EGDR15           ;STATUS
SLINK:  EQU     RELOC+ESLINK           ;GRAPHICS SUB LINKAGE
L00:    EQU     RELOC+EL00             ;SUBROUTINE 00
L01:    EQU     RELOC+EL01             ;SUBROUTINE 01
L02:    EQU     RELOC+EL02             ;SUBROUTINE 02
L03:    EQU     RELOC+EL03             ;SUBROUTINE 03
L04:    EQU     RELOC+EL04             ;SUBROUTINE 04
L05:    EQU     RELOC+EL05             ;SUBROUTINE 05
L06:    EQU     RELOC+EL06             ;SUBROUTINE 06
L07:    EQU     RELOC+EL07             ;SUBROUTINE 07
L10:    EQU     RELOC+EL10             ;SUBROUTINE 10
L11:    EQU     RELOC+EL11             ;SUBROUTINE 11
L12:    EQU     RELOC+EL12             ;SUBROUTINE 12
L13:    EQU     RELOC+EL13             ;SUBROUTINE 13
L14:    EQU     RELOC+EL14             ;SUBROUTINE 14
L15:    EQU     RELOC+EL15             ;SUBROUTINE 15
L16:    EQU     RELOC+EL16             ;SUBROUTINE 16
L17:    EQU     RELOC+EL17             ;SUBROUTINE 17
SLONG:  EQU     RELOC+ESLONG           ;GRAPHICS SUB LENGTH
S00:    EQU     RELOC+ES00             ;SUBROUTINE 00
S01:    EQU     RELOC+ES01             ;SUBROUTINE 01
S02:    EQU     RELOC+ES02             ;SUBROUTINE 02
S03:    EQU     RELOC+ES03             ;SUBROUTINE 03
S04:    EQU     RELOC+ES04             ;SUBROUTINE 04
S05:    EQU     RELOC+ES05             ;SUBROUTINE 05
S06:    EQU     RELOC+ES06             ;SUBROUTINE 06
S07:    EQU     RELOC+ES07             ;SUBROUTINE 07
S10:    EQU     RELOC+ES10             ;SUBROUTINE 10
S11:    EQU     RELOC+ES11             ;SUBROUTINE 11
S12:    EQU     RELOC+ES12             ;SUBROUTINE 12
S13:    EQU     RELOC+ES13             ;SUBROUTINE 13
S14:    EQU     RELOC+ES14             ;SUBROUTINE 14
S15:    EQU     RELOC+ES15             ;SUBROUTINE 15
S16:    EQU     RELOC+ES16             ;SUBROUTINE 16
S17:    EQU     RELOC+ES17             ;SUBROUTINE 17
SPTR:   EQU     RELOC+ESPTR            ;GRAPHICS SUB POINTER
SOFF:   EQU     RELOC+ESOFF            ;GRAPHICS SUB OFFSET
GPC:    EQU     RELOC+EGPC             ;GRAPHICS STACK POINTER
REF:    EQU     RELOC+EREF             ;CURRENT VIEWPORT REF
M:      EQU     RELOC+EM               ;VECTOR DRAWING TEMP
MM:     EQU     RELOC+EMM              ;VECTOR DRAWING TEMP
MN:     EQU     RELOC+EMN              ;VECTOR DRAWING TEMP
SX:     EQU     RELOC+ESX              ;VECTOR DRAWING TEMP
SY:     EQU     RELOC+ESY              ;VECTOR DRAWING TEMP
COLOR:  EQU     RELOC+ECOLOR           ;VECTOR COLOR STORAGE
XERRT:  EQU     RELOC+EXERRT           ;ERROR SERVICE TEMP
NULL:   EQU     RELOC+ENULL            ;FRAME SERVICE
FREE:   EQU     STRUCT+NULL+1          ;START OF FREE RAM
SYMTAB: EQU     5120                   ;START OF SYMBOL TABLE
PTOP:   EQU     6143                   ;TOP OF PRIVATE RAM
CR0:    EQU     7168                   ;COLOR RAM 0
CR1:    EQU     7184                   ;COLOR RAM 1
CR2:    EQU     7200                   ;COLOR RAM 2
RBOTTOM:EQU     8192                   ;START OF REFRESH RAM
RTOP:   EQU     14335                  ;REFRESH TOP SYSTEM 1
        ;
        ;**************************************************
        ;MAIN PROGRAM BLOCK*********************************
        ;**************************************************
        ;
        ; MAIN *********************************************
        ;
        ; MAIN IS THE DRIVER FOR MICROGRAPH. AFTER INITIALIZING
        ; SP, MAIN CALLS INIT. FETCH AND EXEC ARE CALLED IN
        ; TURN TO PROCESS THE GRAPHICS PRIMITIVES.
        ;
        ; CALLS         INIT
        ;               FETCH
        ;               EXEC
        ;
        ; CALLED BY     NOT APPLICABLE
        ;
        ; REGISTERS     SP      (STACK POINTER)
        ;
        ; I/O           NONE
        ;
        ; STRUCTURES    NONE
        ;
008E    313F10  MAIN:   LD      SP,MSTACK       ;INITIALIZE SP
0091    CD3401          CALL    INIT            ;INITIALIZE THE SYSTEM
0094    CDED01  LOOP:   CALL    FETCH           ;FETCH A PRIMITIVE
0097    CD3D02          CALL    EXEC            ;EXECUTE A PRIMITIVE
009A    18F8            JR      LOOP            ;REPEAT INDEFINITELY
        ;
        ;**************************************************
        ;INTERRUPT SERVICE ROUTINES*************************
        ;**************************************************
        ;
        ; XERR *********************************************
        ;
        ; XERR SERVICES AN ERROR CONDITION. XERR IS CALLED UPON
        ; A TRAP TO THE NON MASKABLE INTERRUPT VECTOR.
        ; XERR ALLOWS A SYSTEM RESET, REGISTER DUMP, OR MEMORY
        ; DUMP VIA THE DIAGNOSTIC DIRECTIVES.
        ;
        ; CALLS         SENDBY
        ;
        ; CALLED BY     NON MASKABLE INTERRUPT
        ;
        ; REGISTERS     A       (DUMP)
        ;               B       (DUMP)
        ;               C       (DUMP)
        ;               D       (DUMP)
        ;               E       (DUMP)
        ;               H       (DUMP)
        ;               L       (DUMP)
        ;               IX      (DUMP)
        ;               IY      (DUMP)
        ;               SP      (DUMP)
        ;
        ; I/O           PORT 2  (STATUS)
        ;               PORT 4  (INPUT)
        ;
        ; STRUCTURES    GDR15   (STATUS)
        ;
009C    FB      XERR:   EI                      ;ENABLE INTERRUPTS
009D    F5              PUSH    AF              ;SAVE A AND F
009E    DDCB0FC6        SET     0,(IX+GDR15)    ;SET ERROR
00A2    DDCB0FCE        SET     1,(IX+GDR15)    ;SET ERROR
00A6    DD7E0F          LD      A,(IX+GDR15)    ;GET THE STATUS
```

Listing 2 continued on page 284

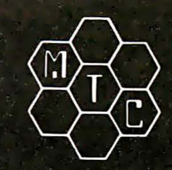
Listing 2 continued:

```
00A9  D302            OUT   (2),A             ;DISPLAY THE STATUS
00AB  DDCBOF66   XERRO:  BIT   4,(IX+GDR15)   ;WAIT FOR DIRECTIVE
00AF  28FA            JR    Z,XERRO           ;JUMP UNTIL RECEIVED
00B1  DB04            IN    A,(4)             ;GET THE DATA
00B3  DDCBOFA6        RES   4,(IX+GDR15)      ;RESET THE STATUS
00B7  F5              PUSH  AF                ;SAVE A AND F
00B8  DD7EOF          LD    A,(IX+GDR15)      ;GET THE STATUS
00BB  D302            OUT   (2),A             ;OUTPUT THE STATUS
00BD  F1              POP   AF                ;RESTORE A AND F
00BE  CB7F            BIT   7,A               ;TEST FOR RESET
00C0  C20000          JP    NZ,RESTART        ;RESTART IF SET
00C3  CB77            BIT   6,A               ;TEST FOR DIRECTIVE
00C5  204F            JR    NZ,XERR1          ;JUMP IF SET
00C7  F1              POP   AF                ;RESTORE A AND F
00C8  F5              PUSH  AF                ;SAVE A COPY OF A AND F
00C9  CD910A          CALL  SENDBY            ;SEND A
00CC  78              LD    A,B               ;GET B
00CD  CD910A          CALL  SENDBY            ;SEND B
00D0  79              LD    A,C               ;GET C
00D1  CD910A          CALL  SENDBY            ;SEND C
00D4  7A              LD    A,D               ;GET D
00D5  CD910A          CALL  SENDBY            ;SEND D
00D8  7B              LD    A,E               ;GET E
00D9  CD910A          CALL  SENDBY            ;SEND E
00DC  7C              LD    A,H               ;GET H
00DD  CD910A          CALL  SENDBY            ;SEND H
00E0  7D              LD    A,L               ;GET L
00E1  CD910A          CALL  SENDBY            ;SEND L
00E4  DD22CA10        LD    (STRUCT+XERRT),IX ;GET IX
00E8  DD7E4A          LD    A,(IX+XERRT)      ;GET LOW BYTE
00EB  CD910A          CALL  SENDBY            ;SEND IT
00EE  DD7E4B          LD    A,(IX+XERRT+1)    ;GET HIGH BYTE
00F1  CD910A          CALL  SENDBY            ;SEND IT
00F4  FD22CA10        LD    (STRUCT+XERRT),IY ;GET IY
00F8  DD7E4A          LD    A,(IX+XERRT)      ;GET LOW BYTE
00FB  CD910A          CALL  SENDBY            ;SEND IT
00FE  DD7E4B          LD    A,(IX+XERRT+1)    ;GET HIGH BYTE
0101  CD910A          CALL  SENDBY            ;SEND IT
0104  D9              EXX                     ;SAVE PRIMARY REGISTERS
0105  2E00            LD    L,0               ;CLEAR POINTER
0107  2600            LD    H,0               ;CLEAR POINTER
0109  39              ADD   HL,SP             ;GET THE STACK POINTER
010A  7D              LD    A,L               ;GET THE LOW BYTE
010B  CD910A          CALL  SENDBY            ;SEND IT
010E  7C              LD    A,H               ;GET THE HIGH BYTE
010F  CD910A          CALL  SENDBY            ;SEND IT
0112  D9              EXX                     ;RESTORE PRIMARY REGS
0113  F1              POP   AF                ;RESTORE A AND F
0114  1895            JR    XERRO             ;DO IT AGAIN
0116  F1         XERR1:  POP   AF             ;POP A AND F
0117  08              EX    AF,AF'            ;SAVE A AND F
0118  D9              EXX                     ;SAVE PRIMARY REGISTERS
0119  DDCBOF66   XERR2:  BIT   4,(IX+GDR15)   ;TEST THE INPUT
011D  28FA            JR    Z,XERR2           ;JUMP IF NOT SET
011F  DB04            IN    A,(4)             ;GET THE DATA
0121  6F              LD    L,A               ;SAVE THE LOW ADDRESS
0122  DDCBOFA6        RES   4,(IX+GDR15)      ;RESET THE FLAG
0126  DD7EOF          LD    A,(IX+GDR15)      ;GET THE STATUS
0129  D302            OUT   (2),A             ;SEND THE STATUS
012B  DDCBOF66   XERR3:  BIT   4,(IX+GDR15)   ;TEST THE INPUT
012F  28FA            JR    Z,XERR3           ;JUMP IF NOT SET
0131  DB04            IN    A,(4)             ;GET THE DATA
0133  67              LD    H,A               ;SAVE THE HIGH ADDRESS
0134  DDCBOFA6        RES   4,(IX+GDR15)      ;RESET THE FLAG
0138  DD7EOF          LD    A,(IX+GDR15)      ;GET THE STATUS
013B  D302            OUT   (2),A             ;SEND THE STATUS
013D  7E              LD    A,(HL)            ;GET THE MEMORY DATA
013E  CD910A          CALL  SENDBY            ;SEND THE DATA
0141  D9              EXX                     ;RESTORE PRIMARY REGS
0142  08              EX    AF,AF'            ;RESTORE A AND F
0143  C3AB00          JP    XERRO             ;DO IT AGAIN
                 ;
                 ; FRAME ************************************
                 ;
                 ; FRAME IS THE INTERRUPT SERVICE ROUTINE FOR A FRAME
                 ; COUNT INTERRUPT (FIRST PRIORITY, MASKABLE INTERRUPT).
                 ; FRAME FIRST SETS THE FRAME INTERRUPT FLAG, INCREMENTS
                 ; THE FRAME COUNT, CALLS NULL, THE FRAME SERVICE
                 ; ROUTINE IN RAM, AND THEN RESETS THE FRAME INTERRUPT
                 ; FLAG. NOTE THAT THE OUTPUT TO THE DISPLAY PORT FORCES
                 ; A RESET OF THE INTERRUPT FOR THE FRAME INTERRUPT,
                 ; SINCE THE INTERRUPT IS PRODUCED ON THIS PORT.
                 ;
                 ; CALLS         NULL
                 ;
                 ; CALLED BY     FIRST PRIORITY MASKABLE INTERRUPT
                 ;
                 ; REGISTERS     A        (TEMPORARY)
                 ;               F        (TEMPORARY)
                 ;               IX       (INDEX)
                 ;
                 ; I/O           PORT 0   (DISPLAY)
                 ;               PORT 2   (STATUS)
                 ;
                 ; STRUCTURES    GDR4     (FRAME COUNT)
                 ;               GDR14    (DISPLAY FORMAT)
                 ;               GDR15    (STATUS)
                 ;
0146  F5         FRAME:  PUSH  AF             ;SAVE A AND F
0147  FB              EI                      ;ENABLE INTERRUPTS
0148  DDCBOFD6        SET   2,(IX+GDR15)      ;SET FRAME INTERRUPT
014C  DD7EOF          LD    A,(IX+GDR15)      ;GET GDR15
014F  D302            OUT   (2),A             ;UPDATE THE STATUS
0151  DD3404          INC   (IX+GDR4)         ;INCREMENT FRAME COUNT
0154  CDCC10          CALL  STRUCT+NULL       ;CALL NULL IN RAM
0157  DD7EOE          LD    A,(IX+GDR14)      ;GET THE DISPLAY FORMAT
015A  D300            OUT   (0),A             ;SEND IT
015C  DDCBOF96        RES   2,(IX+GDR15)      ;RESET FRAME INTERRUPT
0160  DD7EOF          LD    A,(IX+GDR15)      ;GET THE STATUS
0163  D302            OUT   (2),A             ;UPDATE THE STATUS
0165  F1              POP   AF                ;RESTORE A AND F
0166  ED4D            RETI                    ;RETURN FROM INTERRUPT
                 ;
                 ; INPUT ************************************
                 ;
                 ; INPUT IS THE INTERRUPT SERVICE ROUTINE FOR AN INPUT
                 ; INTERRUPT (SECOND PRIORITY, MASKABLE INTERRUPT).
                 ; INPUT SIMPLY SETS THE INPUT INTERRUPT FLAG IN GDR15.
                 ;
                 ; CALLS         NONE
                 ;
                 ; CALLED BY     SECOND PRIORITY MASKABLE INTERRUPT
                 ;
                 ; REGISTERS     A        (TEMPORARY)
                 ;               F        (TEMPORARY)
                 ;               IX       (INDEX)
                 ;
                 ; I/O           PORT 2   (STATUS)
                 ;
                 ; STRUCTURES    GDR15    (STATUS)
                 ;
0168  F5         INPUT:  PUSH  AF             ;SAVE A AND F
0169  FB              EI                      ;ENABLE INTERRUPTS
016A  DDCBOFE6        SET   4,(IX+GDR15)      ;SET INPUT INTERRUPT
016E  DD7EOF          LD    A,(IX+GDR15)      ;GET GDR15
0171  D302            OUT   (2),A             ;UPDATE THE STATUS
0173  F1              POP   AF                ;RESTORE A AND F
0174  ED4D            RETI                    ;RETURN FROM INTERRUPT
                 ;
                 ; OUTPUT ***********************************
                 ;
                 ; OUTPUT IS THE INTERRUPT SERVICE ROUTINE FOR AN OUTPUT
                 ; INTERRUPT (THIRD PRIORITY, MASKABLE INTERRUPT).
                 ; OUTPUT SIMPLY RESETS THE OUTPUT INTERRUPT FLAG IN
                 ; GDR15.
                 ;
                 ; CALLS         NONE
                 ;
                 ; CALLED BY     THIRD PRIORITY MASKABLE INTERRUPT
                 ;
```

Listing 2 continued on page 286



META TECHNOLOGIES



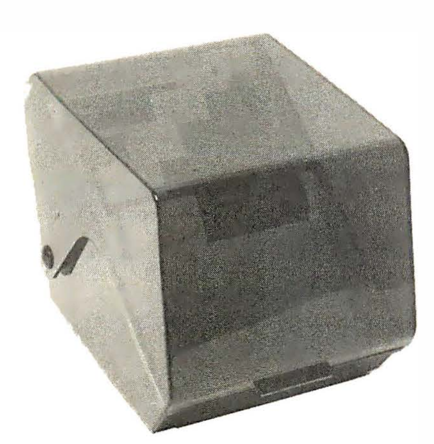
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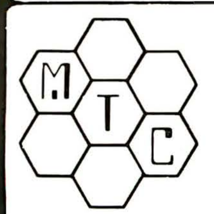
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Listing 2 continued:

```
                ; REGISTERS      A         (TEMPORARY)
                ;                F         (TEMPORARY)
                ;                IX        (INDEX)
                ;
                ; I/O            PORT 2    (STATUS)
                ;
                ; STRUCTURES     GDR15     (STATUS)
                ;
0176  F5        OUTPUT: PUSH AF                      ;SAVE A AND F
0177  FB                EI                           ;ENABLE INTERRUPTS
0178  DDCB0F9E          RES   3,(IX+GDR15)           ;RESET OUTPUT INTERRUPT
017C  DD7E0F            LD    A,(IX+GDR15)           ;GET GDR15
017F  D302              OUT   (2),A                  ;UPDATE THE STATUS
0181  F1                POP   AF                     ;RESTORE A AND F
0182  ED4D              RETI                         ;RETURN FROM INTERRUPT
                ;
                ;*************************************************************
                ;PROCESS DRIVERS**********************************************
                ;*************************************************************
                ;
                ; INIT *******************************************************
                ;
                ; INIT INITIALIZES MICROGRAPH. THE INPUT/OUTPUT PORTS
                ; ARE FIRST SET UP, THEN MEMORY IS CLEARED. INIT THEN
                ; LOADS THE RAM WITH THE STRUCTURES, THEN SET THE
                ; INTERRUPTS.
                ;
                ; CALLS          NONE
                ;
                ; CALLED BY      MAIN
                ;
                ; REGISTERS      A         (TEMPORARY)
                ;                B         (TEMPORARY)
                ;                C         (TEMPORARY)
                ;                D         (TEMPORARY)
                ;                E         (TEMPORARY)
                ;                H         (POINTER)
                ;                L         (POINTER)
                ;                IX        (INDEX)
                ;                IY        (INDEX)
                ;                I         (INTERRUPT VECTOR)
                ;
                ; I/O            ALL PORTS
                ;
                ; STRUCTURES     ALL STRUCTURES
                ;
0184  3E0F      INIT:   LD    A,00001111B            ;LOAD MODE 2 MASK
0186  D301              OUT   (1),A                  ;SET UP DISPLAY
0188  D303              OUT   (3),A                  ;SET UP STATUS
018A  D307              OUT   (7),A                  ;SET UP OUTPUT
018C  3E4F              LD    A,01001111B            ;LOAD MODE 1 MASK
018E  D305              OUT   (5),A                  ;SET UP INPUT
0190  3E68              LD    A,INT0                 ;GET FIRST VECTOR
0192  D301              OUT   (1),A                  ;SET UP FRAME INTERRUPT
0194  3E6A              LD    A,INT1                 ;GET SECOND VECTOR
0196  D305              OUT   (5),A                  ;SET UP INPUT INTERUPT
0198  3E6C              LD    A,INT2                 ;GET THIRD INTERRUPT
019A  D307              OUT   (7),A                  ;SET UP OUTPUT INT
019C  3E07              LD    A,00000111B            ;DISABLE INTERRUPTS
019E  D303              OUT   (3),A                  ;SET STATUS
01A0  3E87              LD    A,10000111B            ;ENABLE INTERRUPTS
01A2  D301              OUT   (1),A                  ;SET DISPLAY
01A4  D305              OUT   (5),A                  ;SET INPUT
01A6  D307              OUT   (7),A                  ;SET OUTPUT
01A8  3E80              LD    A,10000000B            ;SET STATUS
01AA  D302              OUT   (2),A                  ;SET STATUS
01AC  DD218010          LD    IX,STRUCT              ;SET UP IX
01B0  DD360000          LD    (IX+0),0               ;CLEAR FIRST WORD
01B4  218010            LD    HL,STRUCT              ;POINT TO STRUCT
01B7  118110            LD    DE,STRUCT+1            ;POINT TO NEXT STRUCT
01BA  014D00            LD    BC,FREE-STRUCT         ;SET UP COUNT
01BD  EDB0              LDIR                         ;CLEAR PRIVATE RAM
01BF  210400            LD    HL,ESTRUCT             ;POINT TO STRUCTURES
01C2  118010            LD    DE,STRUCT              ;POINT TO STRUCT
01C5  014D00            LD    BC,ENULL-ESTRUCT+1     ;GET THE COUNT
01C8  EDB0              LDIR                         ;LOAD STRUCTURES
01CA  210020            LD    HL,RBOTTOM             ;POINT TO RBOTTOM
01CD  3600              LD    (HL),0                 ;CLEAR FIRST LOCATION
01CF  110120            LD    DE,RBOTTOM+1           ;POINT TO NEXT LOCATION
01D2  010018            LD    BC,RTOP-RBOTTOM+1      ;GET THE COUNT
01D5  EDB0              LDIR                         ;CLEAR REFRESH RAM
01D7  DDCB0FBE          RES   7,(IX+GDR15)           ;CLEAR INIT STATUS
01DB  DD7E0F            LD    A,(IX+GDR15)           ;GET GDR15
01DE  D302              OUT   (2),A                  ;UPDATE STATUS
01E0  3E00              LD    A,0                    ;CLEAR A
01E2  ED47              LD    I,A                    ;SET UP INTERRUPT VECTOR
01E4  ED5E              IM    2                      ;SET INTERRUPT MODE 2
01E6  FB                EI                           ;ENABLE INTERRUPTS
01E7  DD7E0E            LD    A,(IX+GDR14)           ;SET DISPLAY MASK
01EA  D300              OUT   (0),A                  ;SET DISPLAY MODE
01EC  C9                RET                          ;RETURN
                ;
                ; FETCH ******************************************************
                ;
                ; FETCH OBTAINS PRIMITIVES AND DATA FROM THE INPUT
                ; STREAM (FROM THE HOST COMPUTER OR A GRAPHICS
                ; SUBROUTINE IN RAM). FETCH FIRST SETS THE FETCH STATUS.
                ; IF SPTR IS SET, FETCH GETS DATA FROM THE CURRENT
                ; SUBROUTINE POINTER. OTHERWISE, FETCH GETS DATA FROM
                ; PORT 4, THE HOST INPUT. IN ANY CASE, THE PRIMITIVE
                ; OR DATA IS PUT IN REGISTER A. FETCH FINALLY CLEARS
                ; THE FETCH STATUS.
                ;
                ; CALLS          NONE
                ;
                ; CALLED BY      MAIN
                ;                LCRAM
                ;                LPIX
                ;                LREG
                ;                LSUB
                ;                LSYM
                ;                MOV
                ;                RCRAM
                ;                RSYM
                ;                SYM
                ;                VEC
                ;                WAIT
                ;                GETBK
                ;
                ; REGISTERS      A         (RETURNS DATA)
                ;                D         (TEMPORARY)
                ;                D         (POINTER)
                ;                E         (POINTER)
                ;                H         (POINTER)
                ;                L         (POINTER)
                ;                IX        (INDEX)
                ;                IY        (INDEX)
                ;
                ; I/O            PORT 2    (STATUS)
                ;                PORT 4    (INPUT)
                ;
                ; STRUCTURES     GDR15     (STATUS)
                ;                SLINK     (GRAPHICS SUBROUTINE LINKAGE)
                ;                SPTR      (GRAPHICS SUBROUTINE POINTER)
                ;                SOFF      (GRAPHICS SUBROUTINE OFFSET)
                ;
01ED  DDCB0FF6  FETCH:  SET   6,(IX+GDR15)           ;SET FETCH FLAG
01F1  DD7E0F            LD    A,(IX+GDR15)           ;GET GDR15
01F4  D302              OUT   (2),A                  ;UPDATE THE STATUS
01F6  DDCB405E          BIT   3,(IX+SPTR)            ;TEST SPTR
01FA  200F              JR    NZ,FETCH1              ;JUMP IF SUBROUTINE
01FC  DDCB0F66  FETCH0: BIT   4,(IX+GDR15)           ;TEST INPUT INTERRUPT
0200  28FA              JR    Z,FETCH0               ;JUMP IF NO INTERRUPT
0202  DB04              IN    A,(4)                  ;GET DATA FROM HOST
0204  F3                DI                           ;DISABLE THE INTERRUPTS
0205  DDCB0FA6          RES   4,(IX+GDR15)           ;RESET INPUT INTERRUPT
0209  1825              JR    FETCH2                 ;JUMP TO THE EXIT
020B  D5        FETCH1: PUSH  DE                     ;SAVE D AND E
020C  E5                PUSH  HL                     ;SAVE H AND L
020D  FDE5              PUSH  IY                     ;SAVE IY
020F  DD5E40            LD    E,(IX+SPTR)            ;GET SUB POINTER
```

Listing 2 continued on page 288

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Listing 2 continued:

```
0212 CB23                 SLA  E              ;MULTIPLY BY TWO
0214 1600                 LD   D,0            ;CLEAR POINTER
0216 FD219010             LD   IY,STRUCT+SLINK ;LOAD SLINK ADDRESS
021A FD19                 ADD  IY,DE          ;ADD THE OFFSET
021C FD6E00               LD   L,(IY+0)       ;GET LOW BYTE OF ENTRY
021F FD6601               LD   H,(IY+1)       ;GET HIGH BYTE OF ENTRY
0222 DD5E41               LD   E,(IX+SOFF)    ;GET OFFSET
0225 1600                 LD   D,0            ;CLEAR POINTER
0227 DD3441               INC  (IX+SOFF)      ;INCREMENT OFFSET
022A 19                   ADD  HL,DE          ;ADD OFFSET
022B 7E                   LD   A,(HL)         ;GET DATA FROM SUB
022C FDE1                 POP  IY             ;RESTORE IY
022E E1                   POP  HL             ;RESTORE HL
022F D1                   POP  DE             ;RESTORE DE
0230 F5            FETCH2: PUSH AF            ;SAVE A AND F
0231 DDCB0FB6             RES  6,(IX+GDR15)   ;RESET FETCH FLAG
0235 DD7E0F               LD   A,(IX+GDR15)   ;GET GDR15
0238 D302                 OUT  (2),A          ;UPDATE THE STATUS
023A FB                   EI                  ;ENABLE THE INTERRRUPTS
023B F1                   POP  AF             ;RESTORE A AND F
023C C9                   RET                 ;RETURN
                   ;
                   ; EXEC **********************************************
                   ;
                   ; EXEC IS THE FIRST STEP IN EXECUTING A GRAPHICS
                   ; PRIMITIVE. EXECUTE FIRST SETS THE EXECUTE FLAG, THEN
                   ; CALLS PRIMAT, WHICH JUMPS TO THE PROPER PRIMITIVE.
                   ; AFTER A RETURN FROM THE PRIMITIVE ITSELF, EXEC
                   ; RESETS THE EXECUTE FLAG AND RETURNS.
                   ;
                   ; CALLS          PRIMAT
                   ;
                   ; CALLED BY      MAIN
                   ;
                   ; REGISTERS      A        (TEMPORARY)
                   ;                F        (TEMPORARY)
                   ;                IX       (INDEX)
                   ;
                   ; I/O            PORT 2   (STATUS)
                   ;
                   ; STRUCTURES     GDR15    (STATUS)
                   ;
023D F5            EXEC:  PUSH AF             ;SAVE A AND F
023E DDCB0FEE             SET  5,(IX+GDR15)   ;SET EXECUTE FLAG
0242 DD7E0F               LD   A,(IX+GDR15)   ;GET GDR15
0245 D302                 OUT  (2),A          ;UPDATE THE STATUS
0247 F1                   POP  AF             ;RESTORE A AND F
0248 CD5502               CALL PRIMAT         ;CALL PRIMAT
024B DDCB0FAE             RES  5,(IX+GDR15)   ;RESET EXECUTE FLAG
024F DD7E0F               LD   A,(IX+GDR15)   ;GET THE STATUS
0252 D302                 OUT  (2),A          ;UPDATE THE STATUS
0254 C9                   RET                 ;RETURN
                   ;
                   ;*************************************************
                   ;GRAPHICS PRIMITIVES*******************************
                   ;*************************************************
                   ;
                   ; PRIMAT ******************************************
                   ;
                   ; PRIMAT IS THE SECOND STEP IN EXECUTING A PRIMITIVE.
                   ; PRIMAT FIRST DETERMINES THE PRIMITIVE NUMBER FROM THE
                   ; OP CODE IN REGISTER A, AND PUTS A POINTER TO THIS
                   ; ADDRESS IN IY. HL IS THEN LOADED WITH THE SUBROUTINE
                   ; ADDRESS ITSELF, THEN PRIMAT JUMPS TO THIS LOCATION.
                   ; NOTE THAT A RETURN FROM A PRIMITIVE SUBROUTINE
                   ; ACTUALLY RETURNS TO EXEC.
                   ;
                   ; CALLS          NONE
                   ;
                   ; CALLED BY      EXEC
                   ;
                   ; REGISTERS      A        (PRIMITIVE OP CODE)
                   ;                D        (POINTER)
                   ;                E        (POINTER)
                   ;                H        (POINTER)
                   ;                L        (POINTER)
                   ;                IY       (INDEX)
                   ;
                   ; I/O            NONE
                   ;
                   ; STRUCTURES     PENTER   (PRIMITIVE ENTRY POINTS)
                   ;
0255 5F            PRIMAT: LD   L,A           ;SAVE A COPY OF A IN E
0256 CB3B                 SRL  E              ;SHIFT THE OP
0258 CB3B                 SRL  E              ;   CODE RIGHT FOUR
025A CB3B                 SRL  E              ;    BITS TO MAINTAIN
025C CB3B                 SRL  E              ;     THE OFFSET
025E CB23                 SLA  E              ;MULTIPLY BY TWO
0260 1600                 LD   D,0            ;CLEAR THE POINTER
0262 FD216E00             LD   IY,PENTER      ;LOAD PENTER ADDRESS
0266 FD19                 ADD  IY,DE          ;ADD THE OFFSET IN HL
0268 FD6E00               LD   L,(IY+0)       ;LOAD LOW BYTE OF SUB
026B FD6601               LD   H,(IY+1)       ;LOAD HIGH BYTE OF SUB
026E E9                   JP   (HL)           ;JUMP TO SUBROUTINE
                   ;
                   ; CALLS *******************************************
                   ;
                   ; CALLS CALLS A MICROCOMPUTER OR GRAPHICS SUBROUTINE.
                   ; CALLS FIRST DETERMINES WHAT TYPE OF SUBROUTINE IS
                   ; BEING CALLED. IF IT IS A MICROCOMPUTER SUBROUTINE,
                   ; CALLS CALLS THE PROPER SUBROUTINE AS LINKED BY
                   ; SLINK. OTHERWISE, CALLS PUSHES SPTR AND SOFF ON THE
                   ; GRAPHICS SUBROUTINE STACK, AND LOADS THE NEW VALUES
                   ; FOR SPTR AND SOFF. FUTURE DATA FROM FETCH THEN COMES
                   ; FROM THIS GRAPHICS SUBROUTINE UNTIL A RETN IS
                   ; EXECUTED.
                   ;
                   ; CALLS          USER     (INDIRECTLY, BY DEFAULT)
                   ;                GUSER    (INDIRECTLY, BY DEFAULT)
                   ;                USER SUB(INDIRECTLY)
                   ;
                   ; CALLED BY      PRIMAT   (INDIRECTLY)
                   ;
                   ; REGISTERS      A        (PRIMITIVE OP CODE)
                   ;                B        (TEMPORARY)
                   ;                D        (TEMPORARY)
                   ;                E        (TEMPORARY)
                   ;                H        (POINTER)
                   ;                L        (POINTER)
                   ;                IX       (INDEX)
                   ;
                   ; I/O            NONE
                   ;
                   ; STRUCTURES     GPC      (GRAPHICS STACK POINTER)
                   ;                GSTACK   (GRAPHICS STACK)
                   ;                SOFF     (GRAPHICS SUBROUTINE OFFSET)
                   ;                SLINK    (GRAPHICS SUBROUTINE LINKAGE)
                   ;                SPTR     (GRAPHICS SUBROUTINE POINTER)
                   ;
026F CB5F          CALLS: BIT  3,A            ;TEST T BIT IN OP CODE
0271 2014                 JR   NZ,CALLS1      ;JUMP IF GRAPHICS SUB
0273 FD219010             LD   IY,STRUCT+SLINK ;GET LINK BASE
0277 E607                 AND  00000111B      ;MASK ALL BUT SUB
0279 CB27                 SLA  A              ;MULTIPLY BY TWO
027B 5F                   LD   E,A            ;SAVE A IN E
027C 1600                 LD   D,0            ;CLEAR POINTER
027E FD19                 ADD  IY,DE          ;ADD OFFSET TO IY
0280 FD6E00               LD   L,(IY+0)       ;GET LOW ADDRESS
0283 FD6601               LD   H,(IY+1)       ;GET HIGH ADDRESS
0286 E9                   JP   (HL)           ;JUMP TO SUBROUTINE
0287 217F10        CALLS1: LD  HL,GSTACK      ;LOAD GSTACK ADDRESS
028A DD5E42               LD   E,(IX+GPC)     ;GET GPC
028D 1600                 LD   D,0            ;CLEAR POINTER
028F B7                   OR   A              ;RESET THE CARRY
0290 ED52                 SBC  HL,DE          ;SUBTRACT POINTER
0292 DD4640               LD   B,(IX+SPTR)    ;LOAD SPTR
0295 70                   LD   (HL),B         ;PUT SPTR ON GSTACK
0296 DD4641               LD   B,(IX+SOFF)    ;LOAD SOFF
0299 2B                   DEC  HL             ;UPDATE THE POINTER
029A 70                   LD   (HL),B         ;PUT SOFF ON GSTACK
```

Listing 2 continued on page 290

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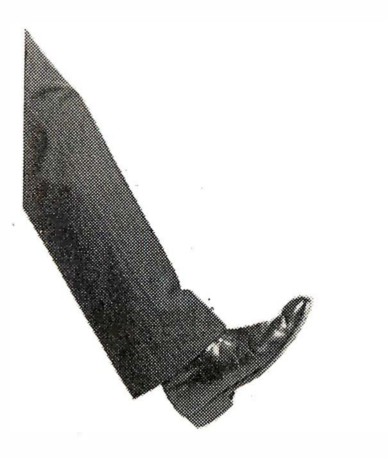
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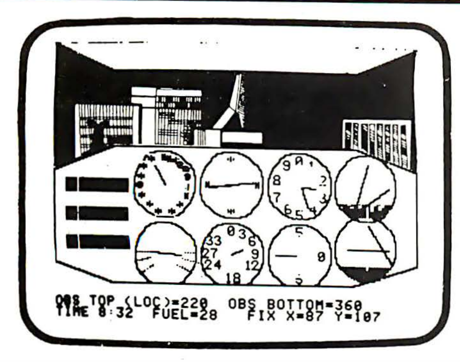
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Listing 2 continued:

```
029B   E60F                 AND   00001111B        ;AND ALL BUT SUB
029D   DD7740               LD    (IX+SPTR),A      ;UPDATE SPTR
02A0   DD364100             LD    (IX+SOFF),0      ;UPDATE SOFF
02A4   DD3442               INC   (IX+GPC)         ;INCREMENT GPC
02A7   DD3442               INC   (IX+GPC)         ;INCREMENT GPC
02AA   C9                   RET                    ;RETURN
                     ;
                     ; LCRAM ************************************************
                     ;
                     ; LCRAM LOADS THE COLOR RAMS. LCRAM FIRST DETERMINES IF
                     ; A SINGLE OR ALL COLOR RAMS ARE TO BE LOADED. IF A
                     ; SINGLE C●L●R RAM IS T● BE LOADED, THE ENTIRE RAM OR
                     ; A SINGLE ADDRESS OF THAT RAM IS TO BE LOADED.
                     ; OTHERWISE, ALL THREE COLOR RAMS ARE EITHER ENTIRELY
                     ; LOADED, OR A SINGLE ADDRESS IN ALL THREE IS LOADED.
                     ;
                     ; CALLS            FETCH
                     ;                  GETBLK
                     ;
                     ; CALLED BY        PRIMAT    (INDIRECTLY)
                     ;
                     ; REGISTERS        A         (PRIMITIVE OF CODE)
                     ;                  B         (COUNTER)
                     ;                  D         (TEMPORARY)
                     ;                  E         (TEMPORARY)
                     ;                  H         (P●INTER)
                     ;                  L         (POINTER)
                     ;                  IY        (INDEX)
                     ;
                     ; I/●              NONE
                     ;
                     ; STRUCTURES       CR0       (COLOR RAM 0)
                     ;                  CR1       (COLOR RAM 1)
                     ;                  CR2       (C●L●R RAM 2)
                     ;
02AB   CB47          LCRAM:  BIT   0,A              ;TEST SINGLE BIT
02AD   2820                  JR    Z,LCRAM1         ;JUMP IF SINGLE
02AF   FE1D                  CP    00011101B        ;TEST FOR ALL
02B1   2009                  JR    NZ,LCRAM0        ;JUMP IF NOT ALL
●2B3   0630                  LD    B,48             ;SET COUNT OF 48 BYTES
02B5   21001C                LD    HL,CR0           ;SET START ADDRESS
02B8   CD9A08                CALL  GETBLK           ;CALL GETBLK
02BB   C9                    RET                    ;RETURN
02BC   0610          LCRAM0: LD    B,16             ;SET COUNT OF 16 BYTES
02BE   E60C                  AND   00001100B        ;MASK OFF ●PCODE
02C0   CB27                  SLA   A                ;SHIFT ●FFSET
02C2   CB27                  SLA   A                ;SHIFT OFFSET
02C4   6F                    LD    L,A              ;SAVE OFFSET
02C5   2600                  LD    H,0              ;CLEAR POINTER
02C7   11001C                LD    DE,CR0           ;GET START ADDRESS
02CA   19                    ADD   HL,DE            ;ADD T● ●FFSET
02CB   CD9A08                CALL  GETBLK           ;CALL GETBLK
02CE   C9                    RET                    ;RETURN
02CF   FE1C          LCRAM1: CP    00011100B        ;TEST FOR ALL
02D1   2027                  JR    NZ,LCRAM2        ;JUMP IF NOT ALL
02D3   CDED01                CALL  FETCH            ;GET OFFSET
02D6   E60F                  AND   00001111B        ;MASK ALL BUT OFFSET
02D8   6F                    LD    L,A              ;SAVE ●FFSET
02D9   2600                  LD    H,0              ;CLEAR POINTER
02DB   110●1C                LD    DE,CR0           ;GET START ADDRESS
02DE   19                    ADD   HL,DE            ;ADD TO OFFSET
02DF   5D                    LD    E,L              ;RESTORE LOW BYTE
02E0   54                    LD    D,H              ;RESTORE HIGH BYTE
02E1   FD210000              LD    IY,0             ;CLEAR INDEX
02E5   FD19                  ADD   IY,DE            ;MOVE POINTER TO INDEX
02E7   CDED01                CALL  FETCH            ;GET DATA
02EA   FD7700                LD    (IY+0),A         ;LOAD DATA IN CR0
02ED   CDED01                CALL  FETCH            ;GET DATA
02F0   FD7710                LD    (IY+16),A        ;LOAD DATA IN CR1
02F3   CDED01                CALL  FETCH            ;GET DATA
02F6   FD7720                LD    (IY+32),A        ;LOAD DATA IN CR2
02F9   C9                    RET                    ;RETURN
02FA   0601          LCRAM2: LD    B,1              ;SET COUNT OF 1 BYTE
02FC   E60C                  AND   00001100B        ;MASK ALL BUT OFFSET
02FE   CB27                  SLA   A                ;SHIFT OFFSET
0300   CB27                  SLA   A                ;SHIFT OFFSET
0302   6F                    LD    L,A              ;SAVE A IN L
0303   2600                  LD    H,0              ;CLEAR POINTER
0305   CDED01                CALL  FETCH            ;GET OFFSET
0308   E60F                  AND   00001111B        ;MASK ALL BUT OFFSET
030A   85                    ADD   A,L              ;ADD OFFSET
030B   6F                    LD    L,A              ;SAVE OFFSET
030C   11001C                LD    DE,CR0           ;GET START ADDRESS
030F   19                    ADD   HL,DE            ;ADD OFFSET
0310   CD9A08                CALL  GETBLK           ;GET DATA
0313   C9                    RET
                     ;
                     ; LPIX ************************************************
                     ;
                     ; LPIX LOADS PIXEL DATA ACCORDING TO THE GIVEN
                     ; REFERENCE. LPIX CAN LOAD EITHER FULL FRAME, ONE
                     ; PIXEL AT XY, OR AN ENTIRE VIEWPORT. THE PIXELS ARE
                     ; LOADED IN EITHER THE PRIMARY COLOR, THE SECONDARY
                     ; COLOR, OR AS SPECIFIED IN THE DATA WHICH FOLLOWS.
                     ; LPIX FIRST CHECKS TO SEE IF ONLY A SINGLE POINT IS
                     ; LOADED. IF SO, LPIX LOADS THE APPR●PRIATE COLOR.
                     ; OTHERWISE, LPIX SETS A FLAG IF THERE IS A FULL FRAME
                     ; L●AD REQUESTED. NEXT, LPIX DETERMINES WHAT C●L●R IS
                     ; REQUESTED. IF THE COLOR DOES NOT FOLLOW, A FLAG IS
                     ; SET, AND THE APPROPRIATE COLOR IS LOADED FROM THE
                     ; GRAPHICS DISPLAY REGISTERS. NEXT, LPIX CLEARS BOTH
                     ; X AND Y, AND PR●CEDES TO LOAD THE PIXELS FROM
                     ; THE ORIGIN OF THE DISPLAY TO THE TOP, ONE LINE AT
                     ; A TIME. CLIP IS CALLED IF THERE IS A VIEWPORT
                     ; REFERENCE TO SEE IF THAT POINT WILL ACTUALLY BE
                     ; LOADED. LPIX IS COMPLETED WHEN X AND Y RECYCLE TO THE
                     ; ORIGIN.
                     ;
                     ; CALLS            FETCH
                     ;                  CASE
                     ;                  CLIP
                     ;                  POKE
                     ;
                     ; CALLED BY        PRIMAT    (INDIRECTLY)
                     ;
                     ; REGISTERS        A         (PRIMITIVE ●F C●DE, TEMPORARY)
                     ;                  B         (CASE)
                     ;                  C         (CLIP SUCCESS FLAG)
                     ;                  D         (FULL FRAME FLAG)
                     ;                  E         (COLOR F●LLOWS FLAG)
                     ;                  IX        (INDEX)
                     ;
                     ; I/O              NONE
                     ;
                     ; STRUCTURES       GRD0      (X)
                     ;                  GDR1      (Y)
                     ;                  GDR2      (PRIMARY COLOR)
                     ;                  GDR3      (SECONDARY COLOR)
                     ;                  REF       (REFERENCE)
                     ;
0314   1E00          LPIX:   LD    E,0              ;CLEAR COLOR FOLLOWS
0316   1600                  LD    D,0              ;CLEAR FULL FRAME
0318   E60F                  AND   00001111B        ;CLEAR OP CODE
031A   DD7743                LD    (IX+REF),A       ;SAVE REFERENCE
031D   DDCB433E              SRL   (IX+REF)         ;ADJUST REFERENCE
0321   DDCB433E              SRL   (IX+REF)         ;ADJUST REFERENCE
0325   CB5F                  BIT   3,A              ;TEST REFERENCE
0327   2821                  JR    Z,LPIX4          ;JUMP IF VIEWPORT REF
0329   CB57                  BIT   2,A              ;TEST REFERENCE
032B   2819                  JR    Z,LPIX3          ;JUMP IF FULL FRAME
032D   CB4F                  BIT   1,A              ;TEST COLOR FOLLOWS
032F   200E                  JR    NZ,LPIX1         ;JUMP IF COLOR FOLLOWS
0331   CB47                  BIT   0,A              ;TEST COLOR TYPE
0333   2805                  JR    Z,LPIX0          ;JUMP IF PRIMARY COLOR
0335   DD7E03                LD    A,(IX+GDR3)      ;LOAD SECONDARY COLOR
0338   1808                  JR    LPIX2            ;JUMP AROUND FETCH
033A   DD7E02        LPIX0:  LD    A,(IX+GDR2)      ;LOAD PRIMARY COLOR
033D   1803                  JR    LPIX2            ;JUMP AROUND FETCH
033F   CDED01        LPIX1:  CALL  FETCH            ;GET THE COLOR DATA
0342   CD390A        LPIX2:  CALL  POKE             ;POKE THE COLOR AT XY
```

Listing 2 continued on page 292

Circle 184 on inquiry card.



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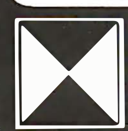
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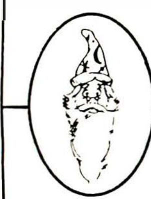
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Circle 187 on inquiry card.

MNEMONIC	NAME
CALL	call subroutine
LCRAM	load color memory
LPIX	load pixel
LREG	load register
LSUB	load subroutine
LSYM	load symbol
MOV	move
RCRAM	read color memory
RET	return
RPIX	read pixel
RREG	read register
RSUB	read subroutine
RSYM	read symbol
SYM	display symbol
VEC	draw a vector
WAIT	wait

Table 2: *Quick reference guide to the primitives defined for Micrograph. Although the minimum set of instructions need only include a point-positioning primitive and a vector-drawing primitive, added flexibility of extra functions is used to remove processing burden from the host system.*

Listing 2 continued:

```
0345   C9                    RET                    ;RETURN
0346   1601       LPIX3:     LD    D,1              ;SET FULL FRAME FLAG
0348   1803                  JR    LPIX5            ;JUMP AROUND CASE
034A   CDA007     LPIX4:     CALL  CASE             ;FIND VIEWPORT CASE
034D   DD360000   LPIX5:     LD    (IX+GDR0),0      ;CLEAR X
0351   DD360100              LD    (IX+GDR1),0      ;CLEAR Y
0355   CB4F                  BIT   1,A              ;TEST COLOR FOLLOWS
0357   200E                  JR    NZ,LPIX7         ;JUMP IF COLOR FOLLOWS
0359   1E01                  LD    E,1              ;SET COLOR FLAG
035B   CB47                  BIT   0,A              ;TEST COLOR TYPE
035D   2805                  JR    Z,LPIX6          ;JUMP IF PRIMARY COLOR
035F   DD7E03                LD    A,(IX+GDR3)      ;LOAD SECONDARY COLOR
0362   1803                  JR    LPIX7            ;JUMP TO LOOP
0364   DD7E02     LPIX6:     LD    A,(IX+GDR2)      ;LOAD PRIMARY COLOR
0367   CB43       LPIX7:     BIT   0,E              ;TEST COLOR FOLLOWS
0369   2003                  JR    NZ,LPIX8         ;JUMP IF COLOR PRESENT
036B   CDED01                CALL  FETCH            ;GET DATA
036E   CB42       LPIX8:     BIT   0,D              ;TEST FULL FRAME
0370   2007                  JR    NZ,LPIX9         ;JUMP IF FULL FRAME
0372   CDEF07                CALL  CLIP             ;CHECK FOR CLIP
0375   CB41                  BIT   0,C              ;TEST SUCCESS
0377   2803                  JR    Z,LPIX10         ;JUMP IF CLIPPED
0379   CD390A     LPIX9:     CALL  POKE             ;POKE THE DATA
037C   DD3400     LPIX10:    INC   (IX+GDR0)        ;INCREMENT X
037F   20E6                  JR    NZ,LPIX7         ;JUMP IF X NOT ZERO
0381   DD3401                INC   (IX+GDR1)        ;INCREMENT Y
0384   20E1                  JR    NZ,LPIX7         ;JUMP IF Y NOT ZERO
0386   C9                    RET                    ;RETURN
                  ;
                  ; LREG **********************************************
                  ;
                  ; LREG LOADS A GRAPHIC DISPLAY REGISTER. IF GDR15 IS
                  ; SPECIFIED, A RESET OCCURS, SINCE THIS IS ESSENTIALLY
                  ; A READ ONLY REGISTER. OTHERWISE, LREG SETS A POINTER
                  ; TO THE APPROPRIATE REGISTER AND READS IN THE DATA.
                  ;
                  ; CALLS          FETCH
                  ;
                  ; CALLED BY      PRIMAT   (INDIRECTLY)
                  ;
                  ; REGISTERS      A        (PRIMITIVE OF CODE, TEMPORARY)
                  ;                D        (TEMPORARY)
```

Text continued from page 278:

features, such as clipping and anti-aliasing, can be readily implemented at the primitive level without the addition of other instructions. Such features can be treated as system parameters, selectable through the load-register primitive. In figure 5, a sample of the images produced by these primitives is shown. (Also see listing 1.)

One last item that must be discussed is error processing. For any implementation of the primitives, the display processor must be able to detect, report, and possibly recover from errors such as invalid primitives or an error in a called user subroutine. Of course, this error processing is highly implementation-dependent, but does not affect the structures of our primitives. However, several of these primitives can be used to aid the host computer in error processing, such as the read-register and read-pixel primitives.

So far the characteristics of interactive computer-graphics systems have been examined, focusing on a comparison of the features of calligraphic and raster-scan display processors. A set of primitive instructions for the control of a color raster-scan display processor have been developed.

Next month, Part 2 of this article will concern the hardware design of Micrograph, a microprocessor-based peripheral which implements these primitives. ■

References

1. "Chip Controls CRT Attributes." *Electronics*, June 1978.
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BYTE's Bugs

Feeling Listless

The performance of a program in the Technical Forum "Some More on Performance Evaluation," by Carl Helmers (July 1980 BYTE, page 216) suffered from one error of substitution and one error of omission.

Listing 1 on page 217, a program submitted by Charles Porter, should contain two lines as follows:

```
105 IF X = L THEN 120
110 IF A(X) = 0 THEN 100
      ELSE 90
```

Thanks to Martin Berman of Teaneck, New Jersey, for pointing this out. ■

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A General Interpolating Graphics Package for the TRS-80

D K Cohen and Devon Crowe
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If you've ever tried creating graph displays with the Radio Shack TRS-80, then you know that the task can be time-consuming. If you haven't tried, you can look forward to the fact that axes must be generated and labelled, and data must be plotted using the awkward screen coordinates of Level II BASIC. After all this has been done, the resulting graph usually is not continuous, but has annoying *holes* in it. But don't despair, because with our simple package that may be implemented as a subroutine plotting X, Y coordinate relations or geometric figures is easy.

In order to use this plotting package effectively, we suggest that you work through each example given. After implementing this package, TRS-80 users should be able to plot any analytic function or set of x and corresponding y values efficiently. This package will allow you to draw axes in the correct quadrant(s) and label them with chosen titles. Tic marks displayed at user-determined intervals, and maximum and minimum values displayed at the correct positions on the graph are also easy to accomplish.

Basic Plotting

The plotting package is divided into two subroutines. The interpolating subroutine (see listing 1) plots the function (or coordinate pairs), interpolating between the points to produce a continuous curve. The resulting curve may be easily displayed at any position of the screen by changing at most four parameters. The program takes care of all scaling problems, and parameters are specified through the use of additional BASIC statements inserted at the front of the subroutine.

With this package, TRS-80 users should be able to plot any analytic function.

To begin this demonstration, suppose you desire to plot the cost of heating a home as a function of the monthly period, displayed in the upper right-hand corner of the screen. (This is done to leave space for other information you may desire to display.) In order to have the graph confined to the desired position, you must specify a *viewport*. For this plotting routine, consider the screen to be divided into one hundred horizontal units and forty vertical units. The bottom left corner corresponds to the screen coordinate (0,0). (See figure 1.) To display the graph in the right-hand corner, the horizontal coordinates should be from 50 to 100, and the vertical coordinates should be from 20 to 40. Thus, to set this viewport, the reader must specify the four variables, Z1, Z2, W1, W2. For this example the viewport variables should be set as follows:

Z1 = 100
Z2 = 50
W1 = 40
W2 = 20

The next step is to set up the x and corresponding y arrays. For example, if during the month of January the heating cost was $80, the first x element would be 1 (for the month) and

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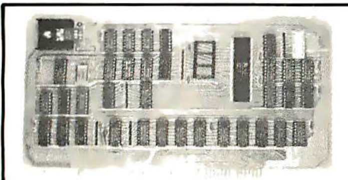
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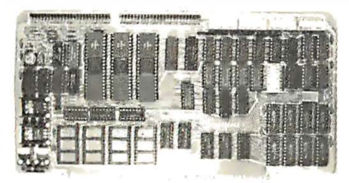
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the *y* element would be 80 (for the cost). Table 1 is a hypothetical set of data to be graphed. The arrays that will contain the data are AX and AY. Thus, for this example, the following BASIC statements should be inserted at the beginning of the subroutine:

```
FOR I=1 TO 12
READ AX(I)
READ AY(I)
NEXT I
DATA 1,80,2,90,3,75,4,50,5,
     45,6,45,7,50,8,80,
     9,70,10,65,11,70,12,80
```

The next variables specify the dimension of the arrays to be graphed. In this example, the minimum dimension TI is 1, the maximum dimension TA is 12, and the separation between the array points IN to be plotted is 1. (For example, if you wanted to plot the cost of heating for every other month, IN would be 2.) Therefore, you must include the following BASIC statements:

```
TI = 1
TA = 12
IN = 1
```

The final variable to be specified, S1, determines the *resolution*, or how well the points are connected in the graph. The value of S1 needed to fully connect all the points depends strongly on the size of the viewport and the number of array points to be plotted. A little experimentation with S1 is necessary to obtain the desired effect. For this demonstration: S1=0.01. After specifying the parameters above, the user is now ready to run the program.

After execution, the results should be as presented in figure 2. To change the viewport, simply change the values in the viewport variables. Figure 3 shows the result when the viewport variables are as follows:

```
Z1 = 100
Z2 =   0
W1 =  40
W2 =   0
```

If you desire to plot the cost of heating for every other month, simply change IN to 2. The results of this change are shown in figure 4.

Adding Axes

At this point, it would be nice to have the axes drawn and labeled. This can be done by specifying four axis parameters for use by the axis-drawing subroutine in listing 2. The first two parameters to be defined are the string variables AX$ and AY$, which define the *x* axis and the *y* axis labels respectively. For this example the *x* axis should be labeled "month" and the *y* axis should be labeled "cost." Thus, the two BASIC statements that must be executed are:

```
AX$ = "MONTH"
AY$ = "  COST"
```

The final two parameters specify the separation of the tic marks on the axes. In the example, set C1 (the *x*-axis tic-mark-separation variable) to 1 for a tic mark every month. Set C2 (the *y*-axis tic-mark-separation variable) to 5 for a tic mark at every $5.00 increment. Thus, the following BASIC statements must be executed:

```
C1 = 1
C2 = 5
```

After execution, the results should be

Text continued on page 310

Listing 1: *The interpolating subroutine. Written in TRS-80 Level II BASIC, this routine plots points on the screen from an array specified by the user. BASIC statements are inserted before the routine is run to create the desired array and, thus, the desired image.*

```
10000 Z2=Z2+25
10005 W2=W2+5
10010 IF Z2>Z1 THEN Z3=Z2 ELSE GOTO 10025
10015 Z2=Z1
10020 Z1=Z3
10025 IF W2>W1 THEN W3=W2 ELSE GOTO 10040
10030 W2=W1
10035 W1=W3
10040 Y1=-1.0E38
10045 Y2=1.0E38
10050 X1=Y1
10055 X2=Y2
10060 FOR I=TI TO TA STEP IN
10065 IF Y1<AY(I) THEN Y1=AY(I)
10070 IF Y2>AY(I) THEN Y2=AY(I)
10075 IF X1<AX(I) THEN X1=AX(I)
10080 IF X2>AX(I) THEN X2=AX(I)
10085 NEXT I
10090 IF Y1=Y2 THEN Y1=1.001*Y1
10095 IF X1=X2 THEN X1=1.001*X1
10100 A=(X1-X2)/(Z1-Z2)
10105 B=(Y1-Y2)/(W1-W2)
10110 FOR I=TI TO TA STEP IN
10115 SET((Z2+(AX(I)-X2)/A), (47-((AY(I)-Y2)/B+W2)))
10120 Q=I+IN
10125 IF Q>TA GOTO 10165
10130 IF AX(I)>AX(Q) THEN SS=-S1 ELSE SS=S1
10135 FOR J=AX(I)TO AX(Q) STEP SS
10140 IF AX(I)=AX(Q) THEN AX(Q)=1.001*AX(Q)+.0000001
10145 Y3=((AY(Q)-AY(I))/(AX(Q)-AX(I)))*(J-AX(I))+AY(I)
10150 SET((Z2+(J-X2)/A),(47-((Y3-Y2)/B+W2)))
10155 NEXT J
10160 NEXT I
10165 RETURN
```

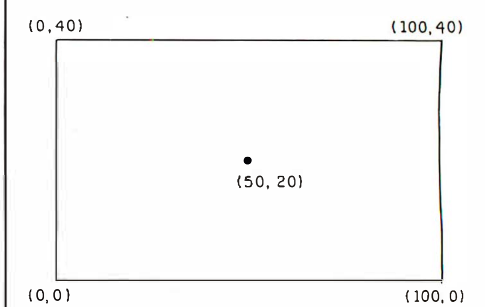



Figure 1: *The TRS-80 video monitor screen is partitioned into one hundred units horizontally and forty units vertically. The bottom left corner of the screen corresponds to the coordinates (0,0). Coordinates are also used to specify viewports in which the plot is to be displayed.*

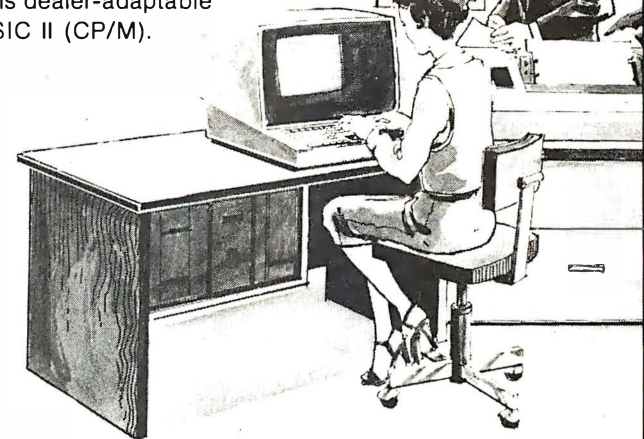
Month	Cost($)
1	80
2	90
3	75
4	50
5	45
6	45
7	50
8	80
9	70
10	65
11	70
12	80

Table 1: *This hypothetical set of data represents the heating costs incurred in a house. Plotted as in figure 2, the information may be limited to one area of the screen or may use the whole screen, as in figure 3.*

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Figure 2: *The information of table 1 is plotted as shown here. The size and location of the* viewport *used were specified by limiting the display area to the bounds of 50 to 100 and 20 to 40.*

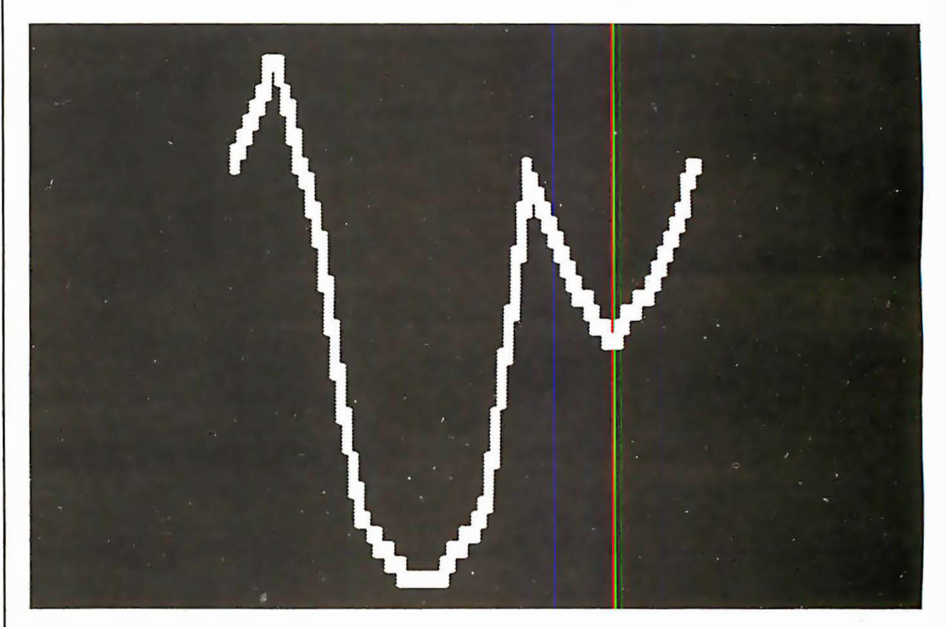


Figure 3: *The information of table 1 is plotted again, with the* viewport *bounds set at 0 to 100 and 0 to 40 (whole screen).*

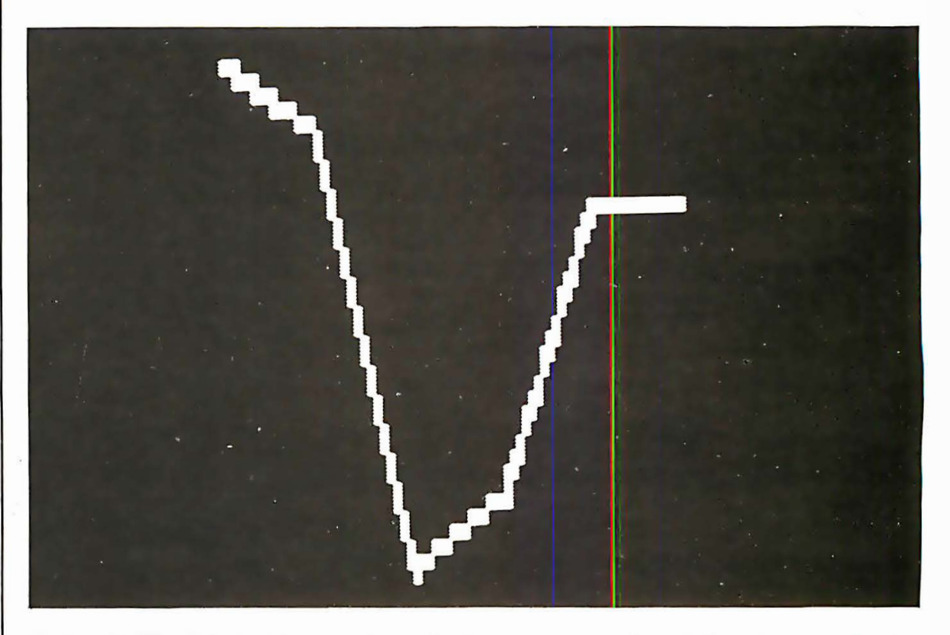


Figure 4: *The information, as in table 1, may be condensed by changing the IN variable. The integer value specified allows the program to plot a reduced number of values from the array. Also, varying the S1 parameter may help to close gaps that occur between plotting points.*

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19 = PRINT YEAR AUDIT
20 = PRINT PROFIT/LOSS ACCOUNT
21 = UPDATE END MONTH FILES MAINTENANCE
22 = PRINT CASH FLOW FORECAST
23 = ENTER/UPDATE PAYROLL (NOT YET AVAILABLE)
24 = RETURN TO BASIC

WHICH ONE? (ENTER 1-24)
01 SUB. MENU EXAMPLE: 01 = EXAMINE: 02 = INSERT: 03 = AMEND: 04 = DELETE
05 = PRINT (1,2,3): 06 = NUMERIC COMBINATIONS: 07 = SORT
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Circle 206 on inquiry card.

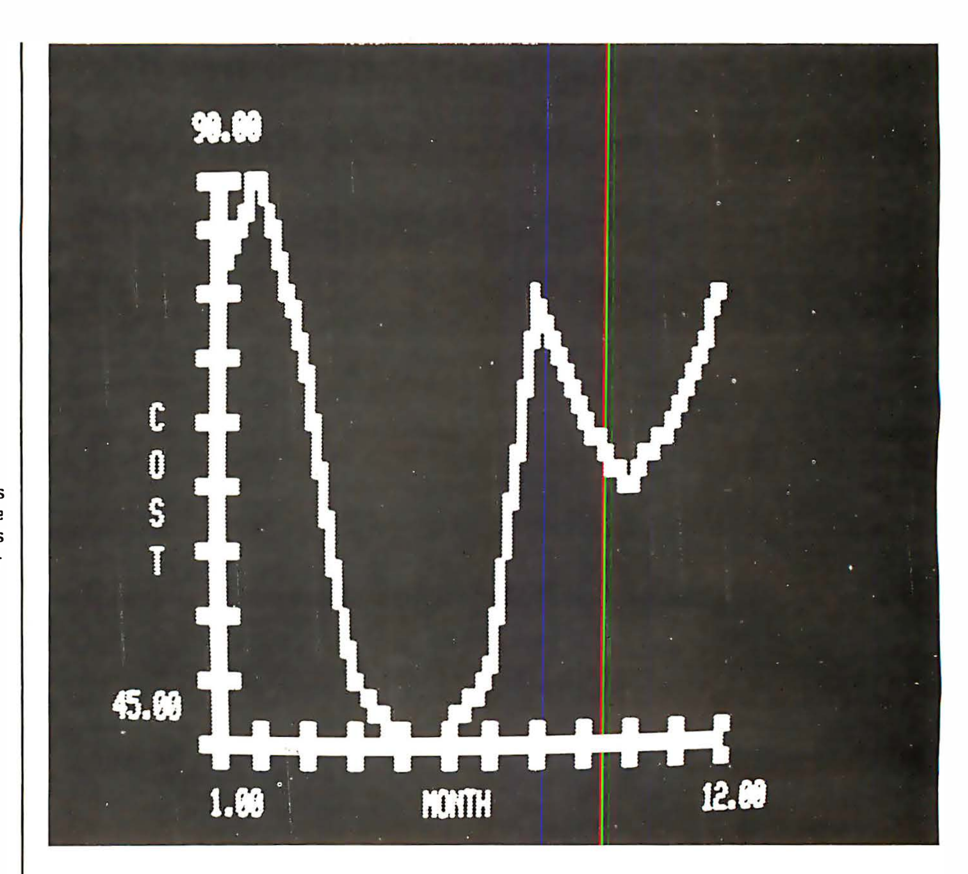


Figure 5: *The axis-plotting subroutine provides for labeling and scaling of the display. The user only needs to specify increments for each scale.*

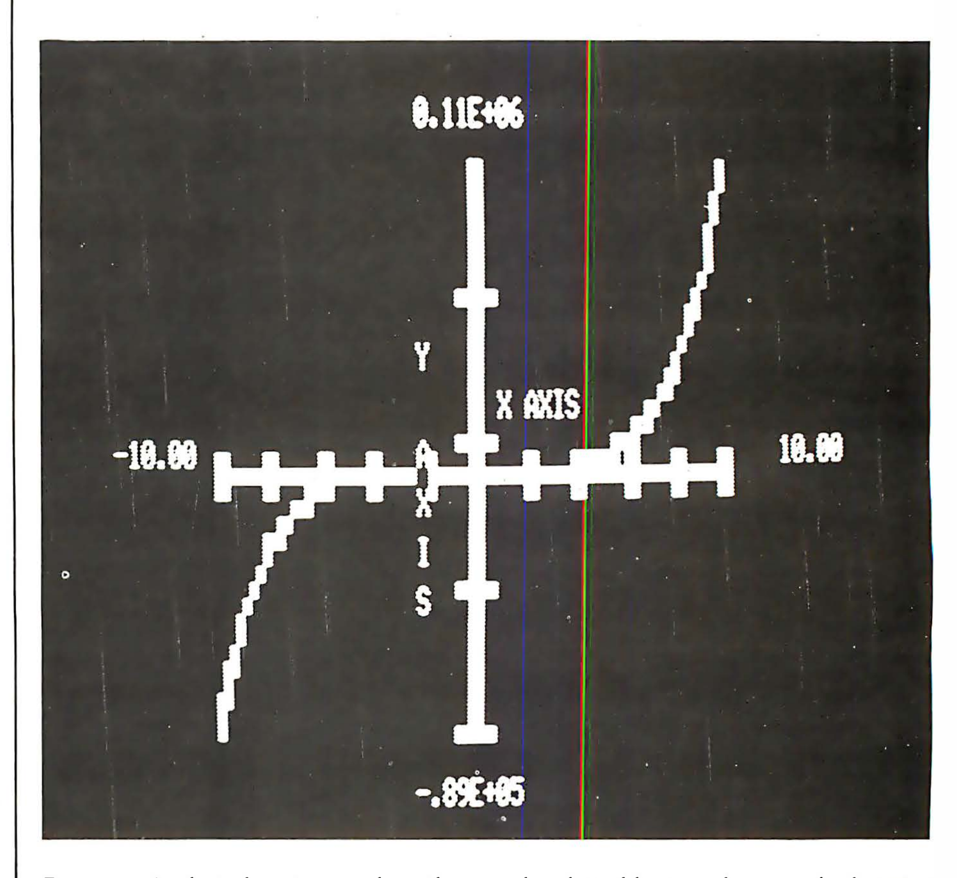
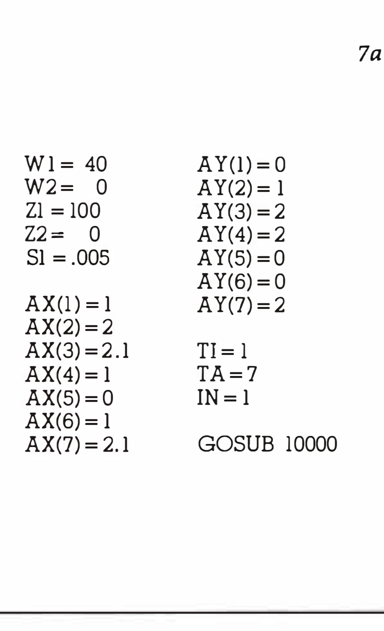


Figure 6: *Analytic functions such as this may be plotted by transforming the function into an array. Usually, a short BASIC routine may be inserted before the plotting routines, depending on the complexity of the desired display.*

7a



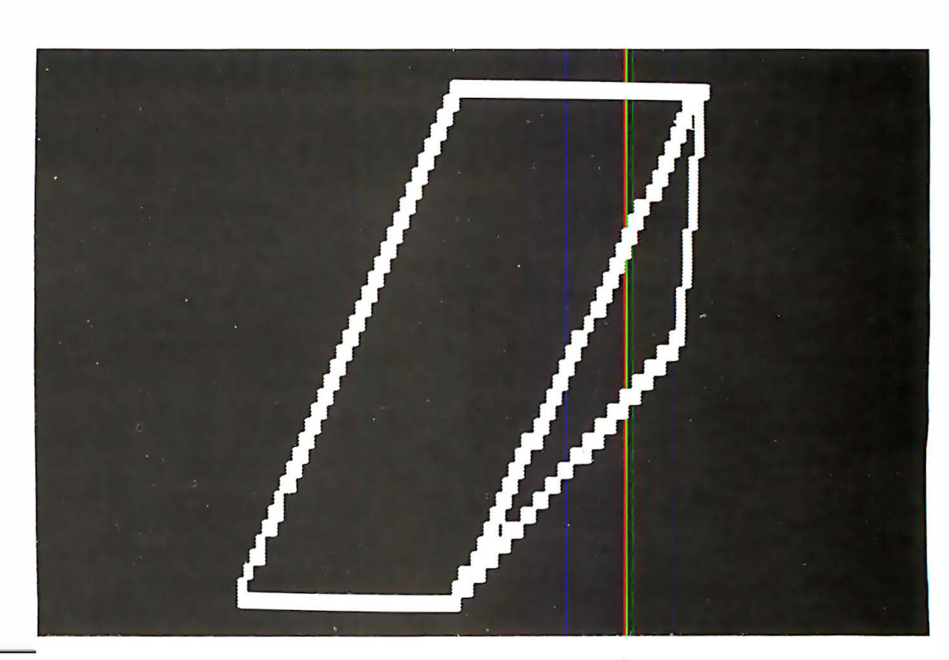
```
W1= 40
W2=  0
Z1 = 100
Z2=  0
S1 = .005

AX(1) = 1
AX(2) = 2
AX(3) = 2.1
AX(4) = 1
AX(5) = 0
AX(6) = 1
AX(7) = 2.1

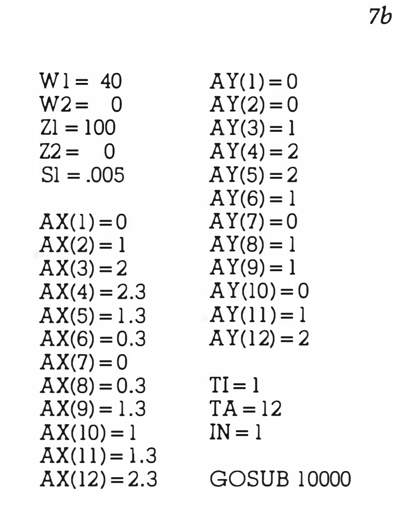
AY(1) = 0
AY(2) = 1
AY(3) = 2
AY(4) = 2
AY(5) = 0
AY(6) = 0
AY(7) = 2

TI = 1
TA = 7
IN = 1

GOSUB 10000
```



7b



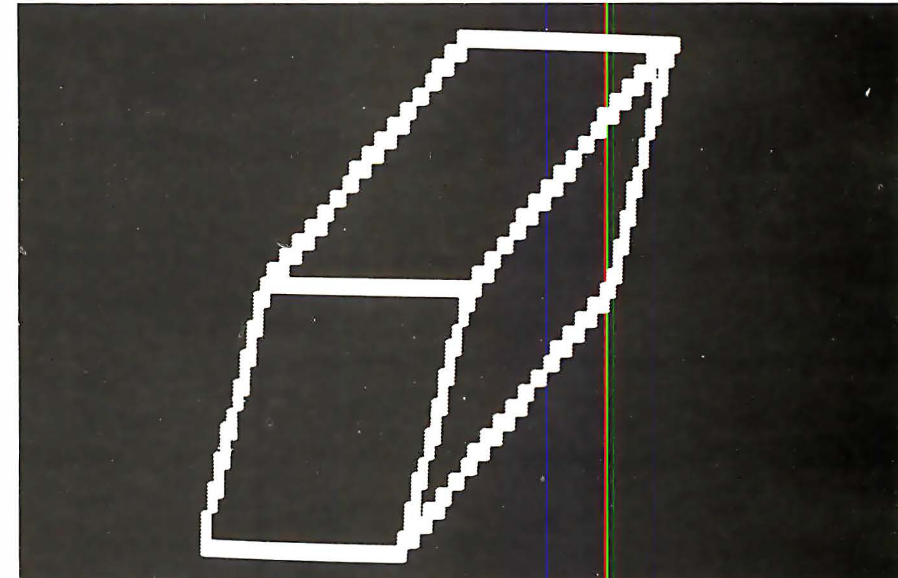
```
W1= 40
W2=  0
Z1 = 100
Z2=  0
S1 = .005

AX(1) = 0
AX(2) = 1
AX(3) = 2
AX(4) = 2.3
AX(5) = 1.3
AX(6) = 0.3
AX(7) = 0
AX(8) = 0.3
AX(9) = 1.3
AX(10) = 1
AX(11) = 1.3
AX(12) = 2.3

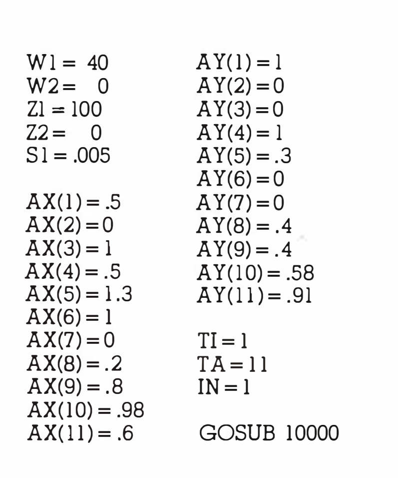
AY(1) = 0
AY(2) = 0
AY(3) = 1
AY(4) = 2
AY(5) = 2
AY(6) = 1
AY(7) = 0
AY(8) = 1
AY(9) = 1
AY(10) = 0
AY(11) = 1
AY(12) = 2

TI = 1
TA = 12
IN = 1

GOSUB 10000
```



7c



```
W1= 40
W2=  0
Z1 = 100
Z2=  0
S1 = .005

AX(1) = .5
AX(2) = 0
AX(3) = 1
AX(4) = .5
AX(5) = 1.3
AX(6) = 1
AX(7) = 0
AX(8) = .2
AX(9) = .8
AX(10) = .98
AX(11) = .6

AY(1) = 1
AY(2) = 0
AY(3) = 0
AY(4) = 1
AY(5) = .3
AY(6) = 0
AY(7) = 0
AY(8) = .4
AY(9) = .4
AY(10) = .58
AY(11) = .91

TI = 1
TA = 11
IN = 1

GOSUB 10000
```

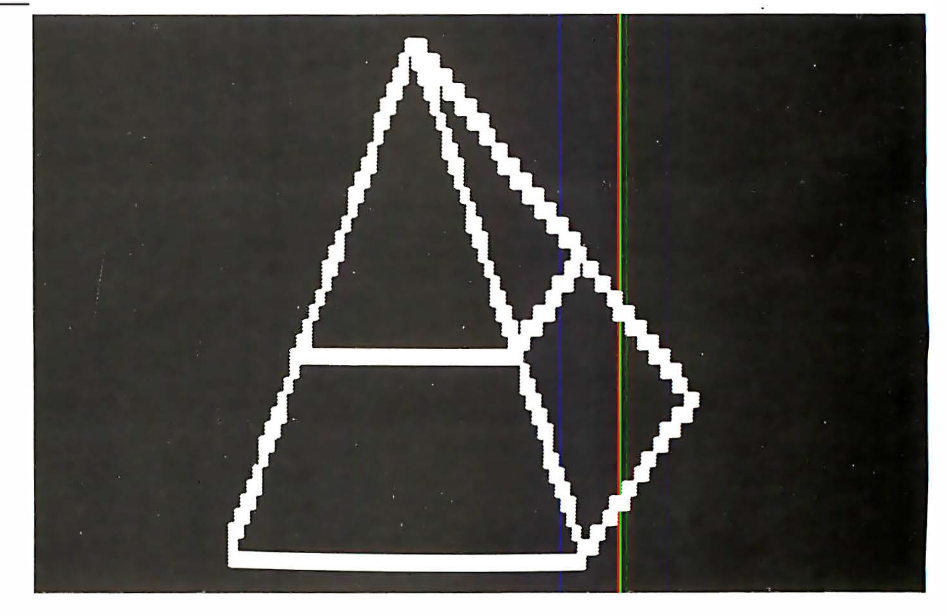
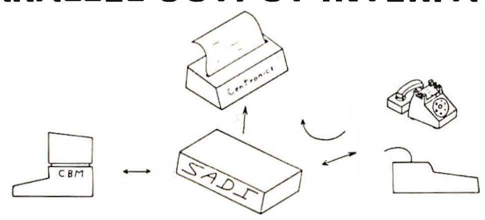


Figure 7: *Three-dimensional displays are also achieved through the transformation to an array.*

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Listing 2: *The axis-creating subroutine shown here produces properly scaled axes, complete with tic marks and labels, from a set of values specified by inserting BASIC statements.*

```
20000 IF X1< =0 AND X2< =0 THEN A1 =Z1 ELSE A1 =Z2
20005 IF X1> =0 AND X2< =0 THEN A1 =Z2 - X2/A
20010 FOR I1 =0 TO 1
20015 FOR J1 =W2 TO W1
20020 SET ((A1 + I1),(47 - J1))
20025 NEXT J1
20030 NEXT I1
20035 IF Y1< =0 AND Y2< =0 THEN B1 =47 - W1 ELSE B1 = 47 - W2
20040 IF Y1> =0 AND Y2< =0 THEN B1 =47 - W2 + Y2/B
20045 FOR I3=Z2 TO Z1
20050 SET(I3,B1)
20055 NEXT I3
20060 FOR I5=1 TO 3 STEP 2
20065 FOR J5=0 TO 1
20070 FOR K5=X2 TO X1 STEP C1
20075 SET(((K5 - X2)/A + Z2 + J5),(B1 - I5 + 2))
20080 NEXT K5
20085 NEXT J5
20090 NEXT I5
20095 FOR I6=0 TO 4 STEP 2
20100 FOR J6=2 TO 3
20105 FOR K6=Y2 TO Y1 STEP C2
20110 SET((A1 + J6 - I6),(47 - ((K6 - Y2)/B + W2)))
20115 NEXT K6
20120 NEXT J6
20125 NEXT I6
20130 IF B1< >47 - W2 GOTO 20145
20135 IF A1 =Z2 - X2/A THEN P1 = -64 ELSE P1 =64
20140 IF A1 =Z2 THEN P2= -4 ELSE P2=4
20145 IF B1< >47 - W1 GOTO 20160
20150 IF A1 =Z2 - X2/A THEN F1 =64 ELSE P1 = -64
20155 IF A1 =Z2 THEN P2= -4 ELSE P2=4
20160 IF B1< >47 - W2 + Y2/B GOTO 20175
20165 P1 = -64
20170 IF A1 =Z2 THEN P2=4 ELSE P2= -4
20175 Z3=LEN(AX$)
20180 Z4=(Z1 + Z2)/2
20185 I7=0
20190 FOR J7=3 TO 45 STEP 3
20195 IF B1<J7 GOTO 20210
20200 I7=I7+64
20205 NEXT J7
20210 Z5=Z4/2 +I7 - Z3/2
20215 IF A1 =Z2 - X2/A AND B1 =47 - W2 + Y2/B THEN DU =5 ELSE DU =0
20220 PRINT @ Z5+P1 +DU, AX$,
20225 W3=LEN(AY$)
20230 FOR I8=1 TO W3
20235 F$(I8)=MID$(AY$, I8, 1)
20240 NEXT I8
20245 W4=(W1 + W2)/2
20250 J6=0
20255 FOR K8=3 TO 45 STEP 3
20260 IF 47 - W4<K8 GOTO 20275
20265 J8=J8+64
20270 NEXT K8
20275 W5=J8+A1/2 - (INT(W3/2) - 1)*64
20280 L8=0
20285 FOR M8=W5 TO (W5+(W3 - 1)*64) STEP 64
20290 L8=L6+1
20295 PRINT @ M6+P2,F$(L8);
20300 NEXT M8
20305 F1(1)=47 - W1
20310 F1(2)=47 - W2
20315 F1(3)=B1
20320 F1(4)=B1
20325 F3(1)=A1/2
20330 F3(2)=A1/2
20335 F3(3)=Z1/2
20340 F3(4)=Z2/2
20345 FOR I9=1 TO 4
20350 J9=0
20355 FOR K9=3 TO 45 STEP 3
20360 IF F1(I9)<K9 GOTO 20375
```

Listing 2 continued on page 310

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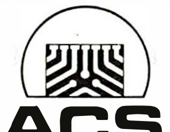
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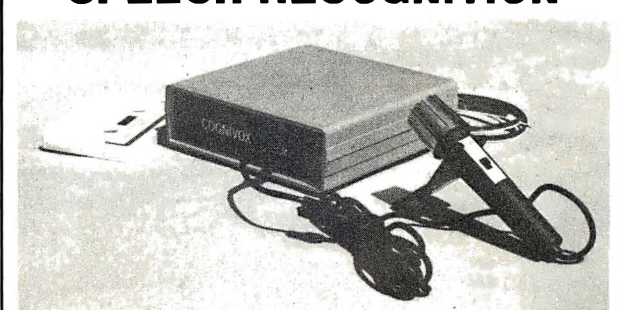


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Circle 217 on inquiry card.

Circle 218 on inquiry card.

Listing 2 continued:

```
20365 J9=J9+64
20370 NEXT K9
20375 F2(I9)=J9+F3(I9)
20380 NEXT I9
20385 IF ABS(Y1)>1E4 OR ABS(Y1)<1E-2 THEN D1$="#.##[[[["
  ELSE D1$="#####.##"
20390 IF ABS(Y2)>1E4 OR ABS(Y2)<1E-2 THEN D2$="#.##[[[["
  ELSE D2$="#####.##"
20395 IF ABS(X1)>1E4 OR ABS(X1)<1E-2 THEN D3$="#.##[[[["
  ELSE D3$="#####.##"
20400 IF ABS(X2)>1E4 OR ABS(X2)<1E-2 THEN D4$="#.##[[[["
  ELSE D4$ ="#####.##"
20405 IF B1<>47-W2+Y2/B GOTO 20435
20410 D1=1
20415 D2=-9
20420 D3=-68
20425 D4=60
20430 GOTO 20505
20435 IF B1<>47-W1 GOTO 20475
20440 D1=-68
20445 D2=-68
20450 D4=60
20455 IF A1=Z1 THEN D3=65
20460 IF A1=Z2 THEN D3=54
20465 IF A1=Z2-X2/A THEN D3=-68
20470 GOTO 20505
20475 D1=60
20480 D2=60
20485 D3=-68
20490 IF A1=Z2 THEN D4=-74
20495 IF A1=Z1 THEN D4=-62
20500 IF A1=Z2-X2/A THEN D4=60
20505 PRINT @ F2(1)+D3,USING D1$;Y1;
20510 PRINT @ F2(2)+D4,USING D2$;Y2;
20515 PRINT @ F2(3)+D1,USING D3$;X1;
20520 PRINT @ F2(4)+D2,USING D4$;X2;
20525 RETURN
```


All scaling and other mundane functions are taken care of in the subroutine.

Text continued from page 298:

displayed as in figure 5. This is for a graph of the cost of heating for every month displayed in the total viewport.

Clearly, it is easy to plot any set of data that can be represented in array form. Remember that all scaling and other mundane functions are taken care of in the subroutines. You don't need to be concerned or irritated by the gyrations needed to create displays on the TRS-80.

Analytic Functions

In order to plot any analytic function, be prepared to transform the function into array form. An example of this is best demonstrated in the plotting of the function:

$$Y = X^5 + X^4 - X^3$$

This is for X taking on values from −10 to 10. In order for this to occur the following BASIC initialization routine is needed:

```
FOR I=-10 TO 10
AX (I+10)=I
AY (I+10)=I↑5+I↑4-I↑3
NEXT I
TI= 0
TA=20
IN= 1
AX$= "X AXIS"
AY$= "Y AXIS"
C1=      2
C2= 49750
```

The result should appear as shown in figure 6. Note that the correct quadrants are displayed.

Another feature provided by this graphics package is the ability to create *three-dimensional* graphs. Figures 7a, b, and c give several examples of this, along with the array values used. The displayed figures are not necessarily functions, but may have more than one *y* value for each value of *x*.

So, creating graphic displays isn't as time-consuming as you might have once believed, and now there's less distance between the creative idea and its final realization on screen. ■

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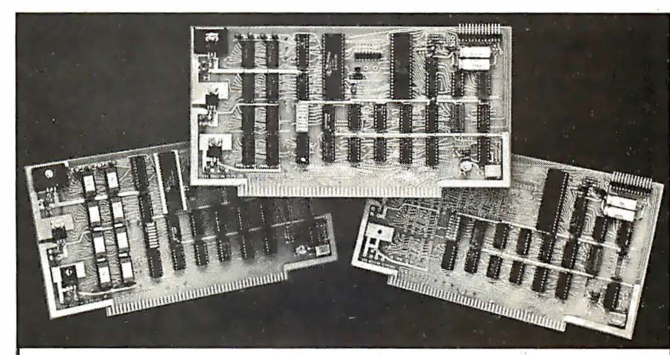


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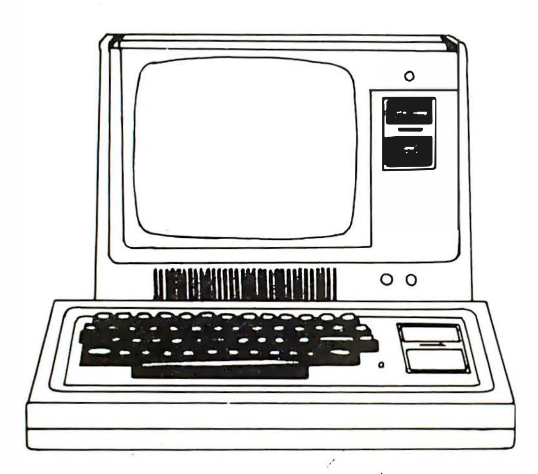
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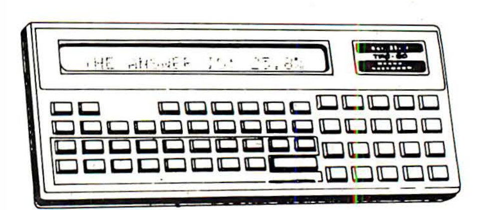
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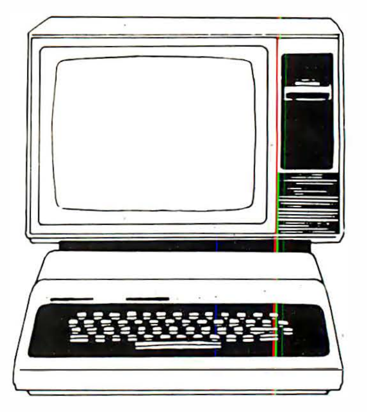


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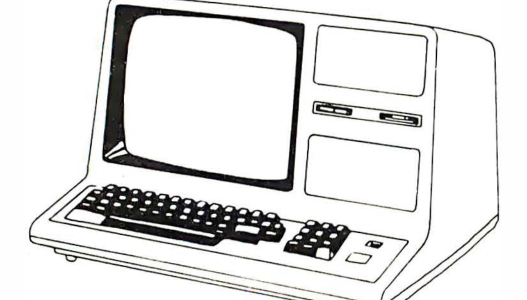
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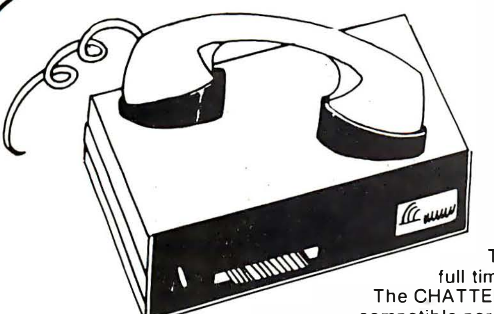


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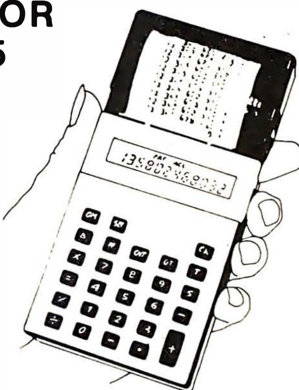
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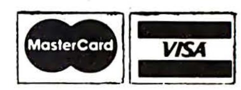


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November-December

Datapro Seminars, throughout the US. Seminars on data communications, teleprocessing software, distributed systems, systems analysis design, word processing, and more, will be given. The enrollment fee is $530 for current Datapro subscribers and $580 for nonsubscribers. For information on when and where the seminars are being held, contact Datapro Research Corporation, 1805 Underwood Blvd, Delran NJ 08075, (609) 764-0100.

November-February

Courses from Harvard, throughout the US, and in London, England. Business graphics, digital-image processing, computer mapping, computer graphics, and information systems for natural resources, are some of the one- and two-day courses being sponsored by the Harvard Graduate School of Design Laboratory for Computer Graphics and Spatial Analysis. For a complete schedule, contact the Laboratory in Cambridge MA 02138, or contact Karen Smolens, Center for Management Research, 850 Boylston St, Chestnut Hill MA 02167.

November 8

Fall 1980 California Com-

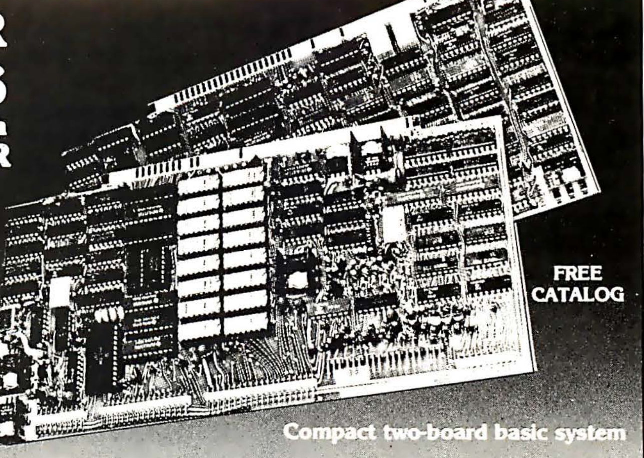
In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc, notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, 70 Main St, Peterborough NH 03458. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

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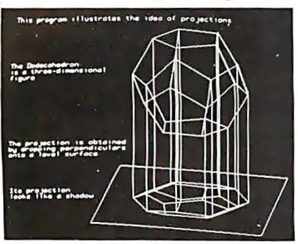
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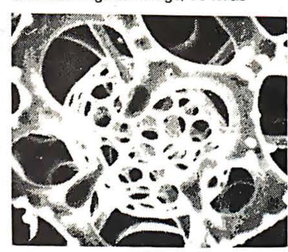
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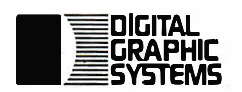
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Manufacturers, stores, and individuals will display both top-of-the-line and used merchandise.

A special consignment table will be available for those who wish to drop off an item or two to be sold during the day. A free literature table is available to anyone within the industry. Admission to buyers will be through the purchase of a redeemable $5 purchase certificate. Sellers, both individuals and companies, should call (415) 966-6546 for booth prices, availability and reservations. Or, write to: California Computer Swap Meets, POB 52, Palo Alto CA 94302.

November 8-9

Personal Computer Fair, Pacific Science Center, Seattle WA. The theme of this year's fair is "Hands On." Both the booths and the exhibits will reflect this idea, and the public will have access to as many computers and terminals as possible. Contact The Northwest Computer Society, POB 4193, Seattle WA 98119, (206) 284-6109.

November 10-13

The Fourth Annual Data-Entry Management Conference, Orlando FL. The theme of this conference is "Improving Productivity and the Quality of Working Life." This conference will cover data entry, distributed processing, and word processing with emphasis on data entry, including human-machine interface. Contact Data Entry Management Association, POB 3231, Stamford CT 06905, (203) 322-1166.

November 11-13

Eleventh Annual Canadian Computer Show and Conference, International Centre, 6900 Airport Rd, Toronto, Ontario. Computers and data-processing equipment, supplies and services, disk drives, terminals and printers, telecommunications equipment, software, and other related items will be displayed. Seminars and tutorials will also be included. Contact Industrial Trade Shows of Canada, 36 Butterick Rd, Toronto, Ontario M8W 3Z8, Canada.

November 12

National Conference on the Use of On-Line Computers in Psychology, St Louis MO. This conference is for computer users in psychology and related disciplines. These users will consider the use of computers in research, clinical practice, and teaching. Tutorial sessions will be included. Contact Dr Dominic Massaro, Program in Experimental Psychology, University of California, Santa Cruz CA 95064.

November 13-16

The 1980 International Computer Music Conference, Queens College, Flushing NY. This conference is for persons interested in computer applications in music. Conference activities include presentation of papers, concerts, workshops, panel discussions, meetings of special interest groups, demonstrations, and an exhibition of computer music equipment. For information, contact Dr Hubert S Howe Jr, Director 1980 International Computer Music Conference, Queens College, Flushing NY 11367, (212) 520-7342.

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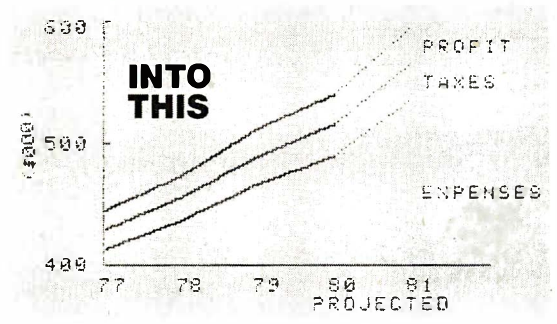
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Comdex, Las Vegas Convention Center, Las Vegas NV. Comdex is a conference and exposition for independent sellers of small-computer and word-processing systems, peripherals, media, and supplies. Address inquiries to The Interface Group, 160 Speen St, Framingham MA 01701, (800) 225-4620.

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Western Educational Computing Conference, San Diego CA. This conference will feature papers and seminars on the use of computing in higher education for instruction, administration, and research. Contact Ron Langley, Director, Computer Center, California State University, Long Beach, 1250 Bellflower Blvd, Long Beach CA 90840, (213) 498-5459.

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Northeast Computer Show, Hynes Auditorium, Boston MA. This exposition is open to the general public. The admission will be $5. Contact National Computer Shows, 824 Boylston St, Chestnut Hill MA 02167, (617) 739-2000.

November 21-23
National Home Entertainment Show, New York Coliseum, New York NY. Exhibits will cover video, photography, audio, games, and home computers. Seminars and demonstrations will be featured in this show. Contact United Business Publications Inc, 475 Park Ave South, New York NY 10016, (212) 725-2300.

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Computer Equipment Registration, George Washington University, Washington DC. This course will review the FCC's Part 15 rules dealing with RF (radio frequency) emissions by computers. Technical considerations governing the classifications for computers, peripherals, and other related devices will be described. Contact the GWU Continuing Engineering Education Program, Washington DC 20052, (800) 424-9773.

November 25-27
Semiconductor International '80, Metropole Convention Centre, Brighton, England. This exhibition is devoted completely to production of semiconductor components, and displays will cover all areas of technology. A technical conference program will cover maskmaking procedures, VLSI (very large-scale integration), crystal growth technology, thin film technology, bonding, memory testing, and more. Contact Kiver Communications SA, 171/185 Ewell Rd, Surbiton, Surrey, KT6 6AX, England.

December 1980

December 2-5
The Eleventh International Conference of the Computer Measurement Group, Sheraton-Boston Hotel, Boston MA. This conference is entitled "Computer Performance Evaluation in the 80s." Contact Judith G Abilock, Price Waterhouse and Company, Office of Government Services, 1801 K St NW, Washington DC 20006, (202) 296-0800.

December 3-5
The 1980 Winter Simulation Conference, Orlando Marriott, Orlando FL. This conference will feature papers, panel discussions, tutorials, and review sessions on discrete and combined simulations. Contact Professor Tuncer I Ören, Chairman, Department of Computer Science, University of Ottawa, Ottawa, Ontario K1N 9B4, Canada, (613) 231-5420.

December 3-5
Implementing Computer-Based Human Resource Systems, New York NY. This is a seminar for planning, organizing, and implementing a comprehensive system for the human resources area. It will demonstrate ways to set up a useful personnel record-keeping system. The course fee is $695. For information, contact The University of Chicago, Center for Continuing Education, MC Seminar Division, 1307 E 60th St, Chicago IL 60637, (800) 223-7450.

December 4
California Computer Shows, Hyatt-Palo Alto, Palo Alto CA. Show hours are from 1 to 7 PM. OEM (original equipment manufacturers) and end-user computer and peripheral products will be exhibited and demonstrated by over sixty companies. Contact Norm De Nardi Enterprises, 95 Main St, Los Altos CA 94022, (415) 941-8440.

December 10
1980 Computer Networking Symposium, Gaithersburg MD. The symposium is sponsored by the IEEE Computer Society, Technical Committee on Computer Communications, and the Institute for Computer Sciences and Technology of the National Bureau of Standards. The focus is on office automation, office system components, and the computer networks required to interconnect them. For information, contact Executive Secretary, POB 639, Silver Spring MD 20901, (301) 439-7007.

January 1981

January 7-9
The Fourteenth International Symposium on Minicomputers and Microcomputers, Hotel del Coronado, San Diego CA. The scope of the symposium will cover technology, hardware, software, engineering, languages, systems architecture, operating systems, numerical methods, computer networks, and other aspects of computing. Contact the Secretary, MIMI '81 San Diego, POB 2481, Anaheim CA 92804.

January 13-15
Communications Networks 1981, Albert Thomas Convention Center, Houston TX. This show will feature exhibits and seminars covering network policy and management for US and international users and carriers; network architecture, software, and hardware; new developments; information appliances; and more. This conference is aimed at communications professionals, carrier, service and

hardware vendors who are interested in combining voice, data, and message systems applications. Contact Communications Networks '81, c/o The Conference Company, 60 Austin St, Newton MA 02160, (617) 964-4550.

January 14-19

42nd National Audio-Visual Convention and Exhibit, Dallas Convention Center, Dallas TX. Over 300 manufacturers and producers of audio-visual, video and microcomputer hardware and software will be exhibiting their products. Seminars will cover marketing and production of audio-visual items. For more information, contact the National Audio-Visual Association, 3150 Spring St, Fairfax VA 22031, (703) 273-7200.

January 16-17

Microcomputer Conference, Arizona State University, Tempe AZ. The goal of this microcomputer conference is to introduce educators to the applications of computers in the classroom. The emphasis of the conference is to provide an awareness of microcomputers and their impact on society. For further information, contact Dr Gary G Bitter, Arizona State University, Payne 203, Tempe AZ 85281.

January 27-29

Advanced Semiconductor Equipment Exposition, San Jose Convention Center, San Jose CA. Over 100 exhibitors will feature equipment at this trade show. The show's emphasis is on new products and emerging technology in the semiconductor processing and production fields. Contact Cartlidge & Associates, 491 Macara Ave, Suite 1014, Sunnyvale CA 94086, (408) 245-6870.

January 28-31

The Third IMMM/Data Comm International Japan Exposition, Harumi Exposition Center, South Hall, Tokyo, Japan. Over 15,000 scientists, design engineers, technical managers, applications engineers, and other specialists are expected to attend this show. Internepcon Japan/Semiconductor International is held concurrently. A conference program will include talks on microcomputer-controlled data communications systems, peripheral interfacing, software management, and more. Contact Industrial and Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606, (312) 263-4866. ■



Correspondence on Correspondence

Thank you, BYTE, for running the enlarged, corrected oscilloscope photographs in BYTE's Bugs on page 182 of the June 1980 issue. BYTE readers may wish to label these pictures in order to be sure of their correspondence with the original photographs on page 66 of the article, "A Computer-Controlled Light Dimmer" (January 1980 BYTE). The picture labels should be matched as follows:

Original Article (January)	Pictures in BYTE's Bugs (June)
00	a
40	b
80	c
C0	d
FF	e

Thank you again for your time and concern in publishing the corrections in BYTE's Bugs.

John H Gibson
Department of Physics
lma College
Alma MI 48801

Incorrect STOIC Price

An incorrect price was reported in John James's article "What is FORTH?" in the August 1980 BYTE. On page 134, middle column, Mr James reported that the language STOIC was available from the CP/M User's Group (1651 Third Ave, New York NY 10028) for $20. The membership fee of $4 has been replaced by a one-time catalog fee of $6, making the total $22, not $20 ($8 each for two floppy disks plus $6 for the catalog). Also, the above price is valid for the United States, Canada, and Mexico only. The price for all other countries is $12 per disk, making a total of $30 ($12 each for two floppy disks plus $6 for the catalog). The Group is filling orders that were received with insufficient funds, but they (and we at BYTE) request that the receivers of such orders pay the appropriate difference in price. ■



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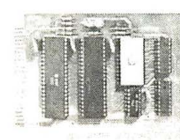
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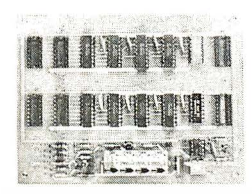


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- 2048 bytes of EPROM (2716)
- Uses one 6522 via (documentation incl.)
  - 2 8-bit bidirectional I/O ports
  - 2 16-bit programmable timer/counter
  - Serial data port
  - Latched output and input with handshaking logic
  - TTL and CMOS compatible

The 6502 microprocessor is particularly suited for control functions such as temperature control burglar alarm, electrical wheel chair, lights, etc. This micro-micro interfaces with the JBE Solid State Switch and A-D and D-A converter and uses JBE 5V power supply. 2716 EPROM is available separately. A 50 pin connector is included.

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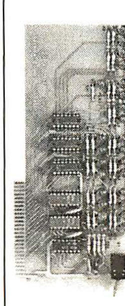
DIMMER CONTROL



The JBE Dimmer Control has 4 channels, 256 brightness levels on-board power supply and four 8-bit parallel input ports (not latched). This board interfaces with JBE Solid State Switch and Apple II Parallel Interface Card (documentation included).

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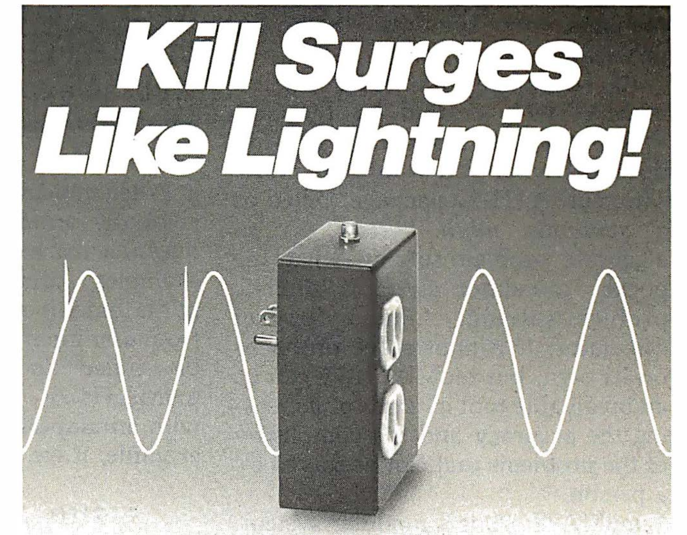


This handy little board is ideal for teaching and trouble-shooting. It has a run-stop single step switch which makes identification of shorted lines between address or data-bits easy & shows single step for teaching computer logic. The display board has 16 address LEDs, 8 data LEDs and 1 RDY LED. All lines are buffered.

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Product Review

The muSIMP/muMATH-79 Symbolic Math System

Gregg Williams
Editor

Computers are very literal minded: ask one to add 1/2 and 1/3 and it will probably give you 0.833333 or some close approximation. Ask for 40! (ie: 40 factorial) and you will get an answer like 8.1592E47, if you receive a reply at all. But what if you wanted the answer 5/6 for the first problem and an exact answer to the second problem, all forty-eight digits of it? Computers express everything in numbers, not symbols: that's the problem.

A software package called muMATH-79, created by the Soft Warehouse of Honolulu, Hawaii, does just what you want and more. The muMATH-79 package, billed as a *symbolic math system*, is to algebraic problem solving what the pocket calculator is to arithmetic problem solving. Like a pocket calculator, it cannot solve problems on its own, but muMATH-79 can be an invaluable tool in terms of increasing the accuracy and the complexity of the problems that can be solved by a person.

muMATH-79 is a modular system. It can be used for any one or a combination of the following: 611-digit arithmetic; matrix manipulation; algebraic manipulation and equation solving; logarithmic and trigonometric manipulation; integration and differentiation.

Arithmetic and Algebra

muMATH-79 manipulates everything as a string of symbols, so it's no surprise that numbers are stored as strings of digits, with a given number being up to 611 digits long. Given this situation, muMATH-79 has defined addition, subtraction, multiplication, division, and integral exponentiation as operations that work on two strings of numbers to give a third string as a result.

Matrix operations in muMATH-79 are fast as well as exact.

When muMATH-79 is running, the computer prompts user input with a question mark and a space. (In our examples, computer-generated output is underlined here to distinguish it from user input.) All commands must be ended in a semicolon, and muMATH-79 precedes its answer with an ampersand and a space. For example, if we type in:

```
? 2↑50;
```

muMATH-79 replies almost instantly with:

```
@ 1125899906842624
```

Similarly, a request for 40 factorial gets an immediate reply:

```
? 40!;
@ 81591528324789773434
  561126959611589427200
  0000000
```

We can assign strings (ie: numbers or symbolic expressions) to variable names using a colon:

```
? C1:2↑50;
@ 1125899906842624
? C2:C1−1;
@ 1125899906842623
```

Also, we can change the radix used to accept and display numbers. For example, to change to binary (also called radix 2 or base 2), we say:

```
? RADIX(2);
@ 1010
```

and muMATH-79 replies that its base was base 10 (since it is now in base 2, it prints 10 in binary: binary 1010 = decimal 10). To check that we are in base 2:

```
? C1;
@ 10000000000000000000
  0000000000000000000000
  000000000
? C2;
@ 11111111111111111111
  111111111111111111111
  111111111
```

Sure enough, C1, being 2^{50}, should be a 1 followed by fifty 0s in binary, and C2 should be fifty 1s.

Also, muMATH-79 is fast. It computed all the above answers in less than 1 second each (running on a Cromemco Z-2D at 4 MHz), and answered 250! (seven lines of numbers) in 31 seconds. (See listing 1.) When a number being computed

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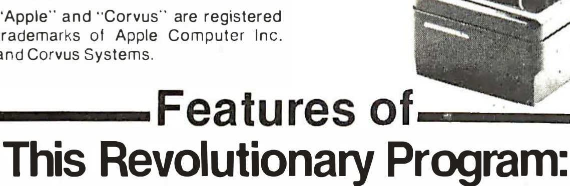
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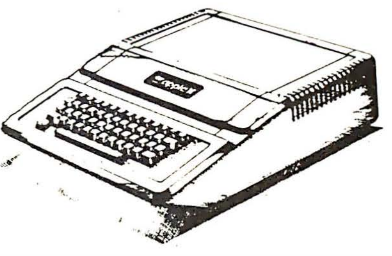
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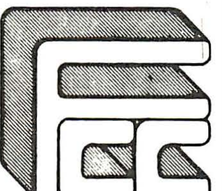
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Listing 1: *Extended-precision arithmetic in muMATH-79. As shown in the first two examples, muMATH-79 does not convert fractions, but rather reduces them to their lowest terms. As you can see from the 493-digit answer to 250! (250 factorial), muMATH-79 does all its arithmetic exactly. In this and all other listings, underlining denotes computer output.*

```
? 4/20;

@ 1 / 5


? 352/283072;

@ 11 / 8846


? 250!;


@ 3232856260909107732320814552024368470994843717673780666747942427112823
747555111209488817915371028199450928507353189432926730931712808990822791
030279071281921676527240189264733218041186261006832925365133678939089569
935713530175040513178760077247933065402339006164825552248819436572586057
399222641254832982204849137721776650641276858807153128978777672951913990
844377478702589172973255150283241787320658188482062478582659808848825548
800000000000000000000000000000000000000000000000000000000000000
```

exceeds the capacity of the system, muMATH-79 replies with the word FALSE:

```
? 300!;
@ FALSE
```

muMATH-79 also manipulates symbolic expressions (depending on the values of its control variables, described later). For example:

```
? 5*X-3*Y↑2+8*X-4*Y↑2
@ 13*X - 7*Y↑2
```

Equations in muMATH-79 are often hard to read. It helps to write them out using pencil and paper; the above was $5X-3Y^2+8X-4Y^2$, which simplified to $13X-7Y^2$. Variables can be used in expressions, where they add their symbolic content to the expression being evaluated:

```
? EXPR1:B+4;
@ 4 + B
? EXPR2:EXPR1+C+2*B;
@ 4 + 3*B + C
```

A variable name is called *bound* if it has a value and *unbound* if it does not. For example, the variable EXPR1, above, is bound because it has the value B+4. There are times, however, when we want a variable to simply be itself. We can change a variable from bound to unbound as follows (using the example of EXPR1):

```
? EXPR1;
@ 4 + B     (EXPR1 is bound)
? EXPR1:'EXPR1
@ EXPR1     (EXPR1 is now
                  unbound)
```

Equation Solving

In addition, some equations can be solved. For example, to solve

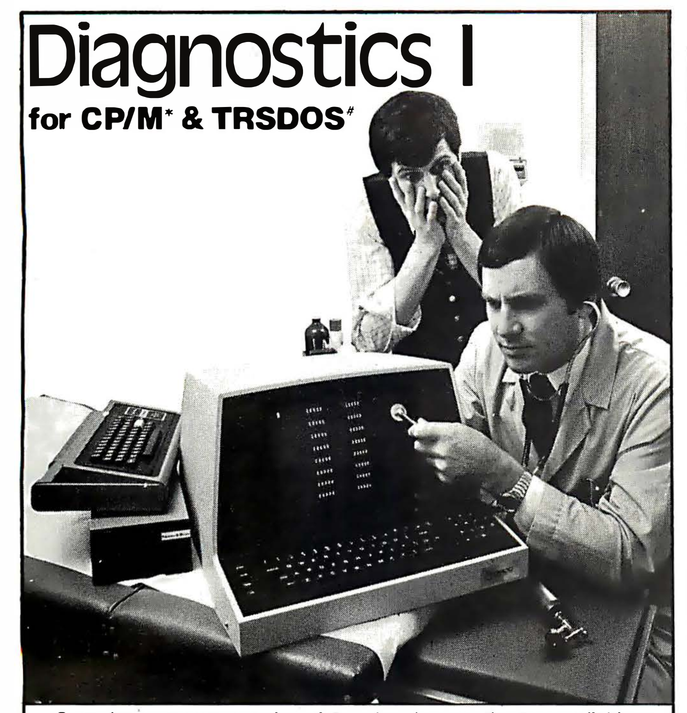
$$X^3+2X^2-63X=0:$$

```
? SOLVE(X↑3+2*X↑
       2-63*X==0,X);
@ {X = 7,
   X = -9,
   X = 0}
```

(muMATH-79 uses the double equal

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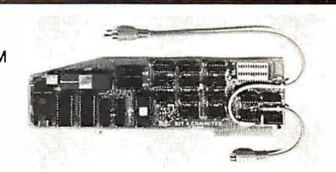


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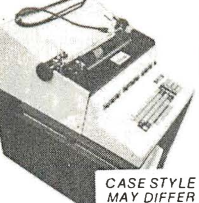
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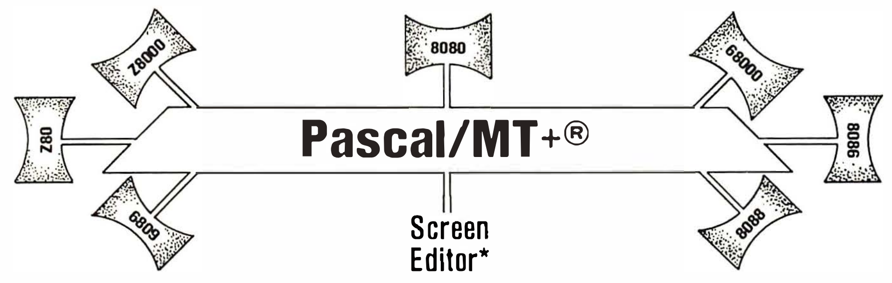
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The most impressive feature of muMATH-79 is its ability to do symbolic differentiation and integration.

sign to distinguish it from the single equal sign, which is used as a Boolean equality operator; the final X in the SOLVE command tells muMATH-79 to solve for the variable X.)

It is also aware of imaginary and complex numbers and uses the variable #I to represent the imaginary number *i*:

```
? SOLVE(X↑2+1==0,X);
@ {X = -#I,
   X = #I}
```

However, muMATH-79 is not intelligent; it cannot solve equations of order 3 or higher. (The example with the X^3 polynomial is seen by muMATH-79 as being of order 2, with a zero factor added.) Factoring is hard even for people, but muMATH-79 can aid you in factoring a higher-order polynomial.

Trigonometric and Logarithmic Manipulation

With the addition of these packages to the muMATH-79 system, the user can manipulate logarithmic and trigonometric expressions. Manipulation of these expressions varies with the values of certain control variables.

For example, if the trigonometric expansion variable TRGEXPD is 0:

```
? SIN(5*Y);
@ SIN(5*Y)
```

But if TRGEXPD is −6 (denoting expansion of multiple-angle sine and cosine functions):

```
? SIN(5*Y);
@ -12*COS(Y)↑2*SIN(Y)
   + 16*COS(Y)↑4*SIN(Y)
   + SIN(Y)
```

The functions available are LN (logarithm to the base *e*), LOG (logarithms to other bases), SIN, COS, TAN, COT, SEC, and CSC. And muMATH-79 uses the variable #E (for *e*) and #PI (for π).

Matrix Manipulations

The math system can also manipulate matrices. Matrices can be multiplied (or divided) by a matrix or a scalar, transposed, inverted, and taken to an integer power. If a matrix is nonsingular (ie: its inverse does not exist), muMATH-79 responds to an attempt to invert it with divide-by-zero error messages. If the matrix can be inverted, the coefficients of its inverse, if nonintegral, are expressed as fractions—that is, the inverse is algebraically exact. For an example of this, see listing 2.

Matrix operations are fast as well as exact. The inversion of matrix H in listing 2 took 5 seconds, and the inversion of a 5-by-5 matrix took 48 seconds. Since matrix entries are symbolic, the entries can be scalars or matrices. This allows the formation of complex data structures that can be manipulated by muMATH-79.

Differentiation and Integration

The most impressive feature of muMATH-79 is its ability to do symbolic differentiation and integration. For example, if we differentiate $1/X^3$ with respect to X, we get $-3X^{-4}$. muMATH-79 accomplishes the task as follows:

```
? DIF(1/X↑3,X);
@ -3 / X↑4
```

Listing 2: *Matrix inversion and multiplication in muMATH-79. Listing 2a shows the creation of the 2 by 2 matrix H. Listing 2b shows the creation of the inverse of H, HINV. Listing 2c shows the multiplication of two compatible matrices using a period (.) as the muMATH-79 matrix multiplication operator.*

(2a)

```
? H:{[380,-115/2],[17,109]};

@ {[380, -115/2],
   [17, 109]}
```

(2b)

```
? HINV:H^-1;

@ {[218/84795, 23/16959],
   [-34/84795, 152/16959]}
```

(2c)

```
? H.HINV;

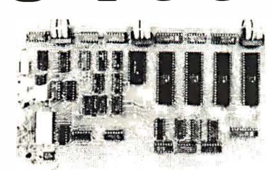
@ {[1, 0],
   [0, 1]}
```

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Listing 3: *Algebraic intergration in muMATH-79. Listing 3a shows the creation of the function FC1, which equals $X^2 + \ln(X)$. Listing 3b shows the calculation of the indefinite integral of FC1, while listing 3c shows the calculation of its definite integral from e to 2e. (See the text for these two equations written in conventional form.)*

```
(3a)   ? FC1:X^2+LN(X);

       @ X^2 + LN(X)

(3b)   ? INT(FC1,X);

       @ -X + X*LN(X) + X^3/3

(3c)   ? DEFINT(FC1,X,#E,2*#E);

       @ -2*#E + 2*#E*LN(2*#E) + 7*#E^3/3
```

It works with the resources of whatever packages are loaded into it at the time. For example, if the trigonometric package is loaded, muMATH-79 can do the following:

```
? DIF(COT(2*X),X);
@ -2 * CSC(2*X)↑2
```

which translates as:

$$\frac{d}{dX} \cot 2X = -2 \csc^2(2X)$$

Indefinite and definite integrals are also within muMATH's capabilities. The definite integral is calculated by simple substitution of the integral limits into the result of the indefinite integration, in much the same process a person performs. If muMATH-79 cannot do this, it simply returns the indefinite integral. Listing 3 shows its calculation of the following two integrals:

$$\int X^2 + \ln(X)\, dX = \frac{X^3}{3} + X \ln(X) - X + C$$

and

$$\int_e^{2e} X^2 + \ln(X) dX = \frac{7e^3}{3} + 2e \ln(2e) - 2e$$

muMATH-79 Control Variables

The package does not exhibit artificial intelligence. (Although with some of its accomplishments, it *seems* to exhibit it.) Rather, it is a very sophisticated symbol manipulator that rigorously applies a given set of rules to arrive at a transformed result. But achieving a desired algebraic manipulation is not always an exact process.

For example, consider the trivial example given in figure 1a. If the denominator is distributed over the numerator, the result is the expression in figure 1b. But if we factor the numerator first, the discovered factor of $(X+1)$ in the numerator cancels the $(X+1)$ in the denominator, leaving the simplified answer in figure 1c.

muMATH-79 cannot make these decisions; it is a tool, not a problem solver. So certain variables called *control variables* are introduced into its environment. Under human control, these variables are used to tell muMATH-79 what manipulations to make.

(a) $\frac{X^3 + X^2}{(X+1)}$

(b) $\frac{X^3}{(X+1)} + \frac{X^2}{(X+1)}$

(c) $\frac{X^3 + X^2}{(X+1)} = \frac{X^2(X+1)}{(X+1)} = X^2$

Figure 1: *Options in the transformation of an algebraic expression. The simple expression in figure 1a can be transformed to that of figure 1b by distributing the denominator over the terms of the numerator. A more useful transformation, however, is shown in figure 1c. By factoring out a term of X^2 and cancelling out the $(X+1)$ factor in both numerator and denominator, the expression can be considerably simplified.*

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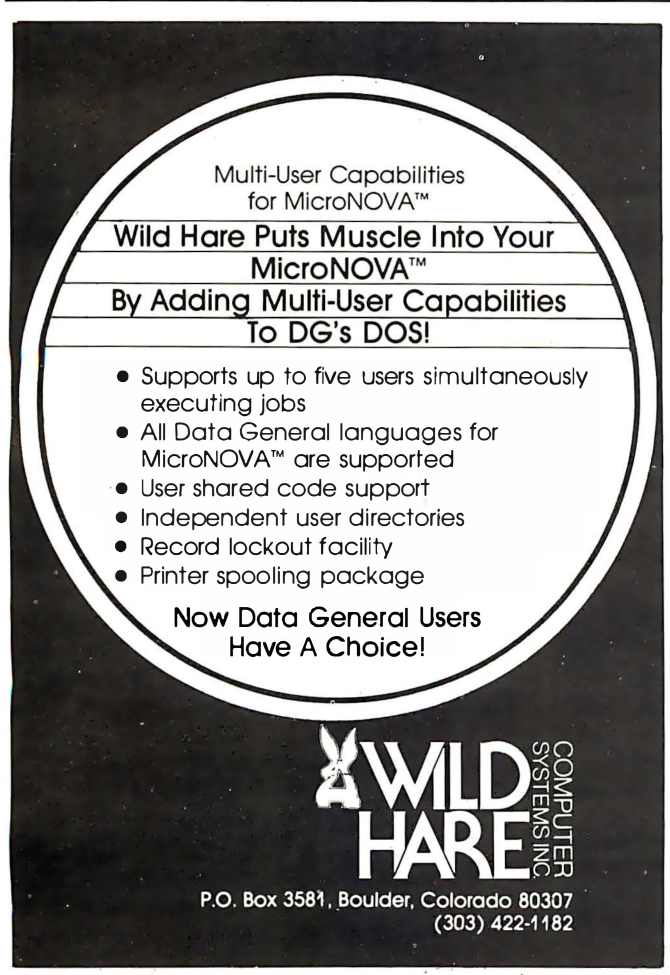
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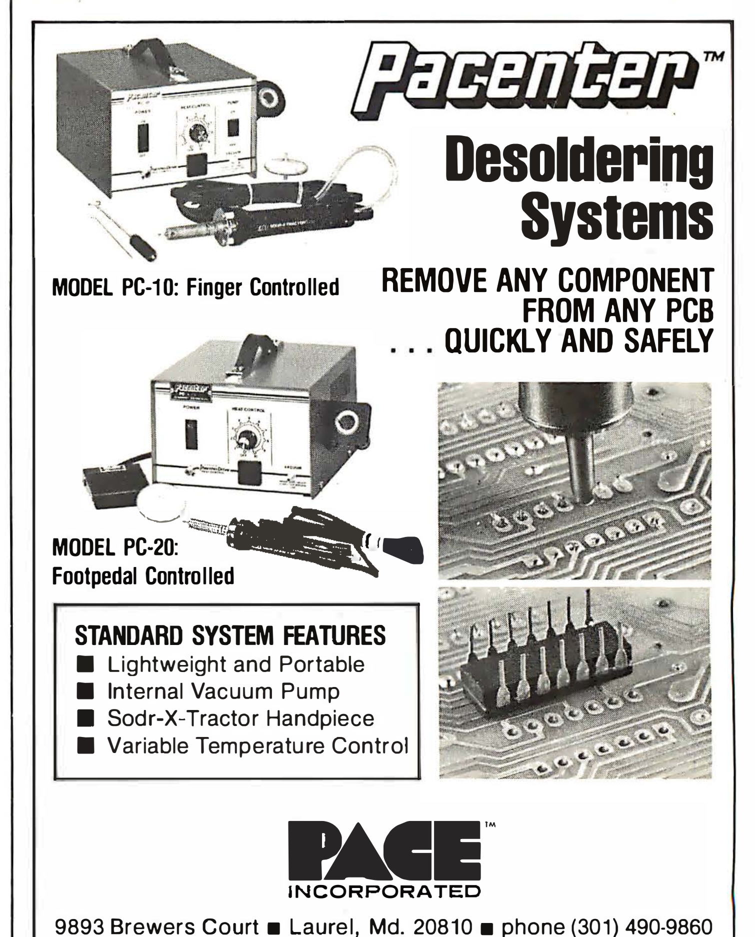
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Although an explanation of the intricacies of control variables is beyond the scope of this review, the topic does deserve some explanation. Table 1 is a list of the control variables and their effects on algebraic expressions. Table 2 shows the effect of one control variable, NUMNUM, on expressions. (Most control variables behave similarly, with positive values causing an expansion of terms to take place and negative values causing a combination of terms to take place.)

Control Variable	Result with Positive Value	Result with Negative Value
NUMNUM	$A(B+C) \rightarrow AB+AC$	$AB+AC \rightarrow A(B+C)$
DENDEN	$\frac{1}{A}\left(\frac{1}{B+C}\right) \rightarrow \frac{1}{AB+AC}$	$\frac{1}{AB+AC} \rightarrow \frac{1}{A}\left(\frac{1}{B+C}\right)$
DENNUM	$\frac{B+C}{A} \rightarrow \frac{B}{A}+\frac{C}{A}$	$\frac{B}{A}+\frac{C}{A} \rightarrow \frac{B+C}{A}$
NUMDEN	$\frac{A}{B+C} \rightarrow \frac{1}{\frac{B}{A}+\frac{C}{A}}$	$\frac{1}{\frac{B}{A}+\frac{C}{A}} \rightarrow \frac{A}{B+C}$
BASEXP	$A^{B+C} \rightarrow A^B A^C$	$A^B A^C \rightarrow A^{B+C}$
EXPBAS	$(AB)^C \rightarrow A^C B^C$	$A^C B^C \rightarrow (AB)^C$
PWREXPD	$(A+B)^2 \rightarrow A^2+2AB+B^2$	$(A+B)^{-2} \rightarrow \frac{1}{(A^2+2AB+B^2)}$
	$(A+B)^3 \rightarrow A^3+3A^2B+B^3$	$(A+B)^{-3} \rightarrow \frac{1}{A^3+3A^2B+3AB^2+B^3}$
	(etc)	(etc)

Table 1: *The effect of control variables on symbolic manipulation within muMATH-79. The values given to these control variables determine how muMATH-79 manipulates algebraic expressions. Other control variables not listed in this table are TRGSQ, TRGEXPD, LOGBAS, PBRCH, and LOGEXPD, which control trigonometric and logarithmic expressions.*

Value of NUMNUM	Transformation	Example
0	do nothing	$3A(B+C)(D+E) \rightarrow 3A(B+C)(D+E)$
2 and its multiples	distribute constants over sums	$\rightarrow A(3B+3C)(D+E)$
3 and its multiples	distribute monomials over sums	$\rightarrow 3(AB+AC)(D+E)$
5 and its multiples	distribute sums over sums	$\rightarrow 3A(D(B+C)+E(B+C))$
6 (=2•3)	distribute constants and monomials over sums	$\rightarrow (3AB+3AC)(D+E)$
10 (=2•5)	distribute constants and sums over sums	$\rightarrow A(D(3B+3C)+E(3B+3C))$
15 (=3•5)	distribute monomials and sums over sums	$\rightarrow 3(ABD+ABE+ACD+ACE)$
30 (=2•3•5)	distribute constants, monomials, and sums over sums	$\rightarrow 3ABD+3ABE+3ACD+3ACE$
−2, −3, −6	same as 2, 3, 6, only factor out instead of distribute	NUMNUM = −3 causes $3AB+3AC \rightarrow A(3B+3C)$

Table 2: *A detailed example of the effect of the control variable NUMNUM on algebraic expressions. NUMNUM is so named because it controls the distribution or factoring of a numerator expression with the numerator expression containing it. Positive values cause a factor to be distributed across a sum, while negative values cause factoring a common value from a sum.*

Generating a muMATH-79 System

Because muMATH-79 can potentially use more than 64 K bytes of memory, the system is supplied as a series of packages that can be combined to create an optimal environment for a given purpose. Figure 2 shows a *dependency diagram* from the muMATH-79 packages as they are supplied. To run a given package, you must load that package and all the packages above it. For example, to manipulate algebraic and logarithmic expressions, you must load the file named MUSIMP79 (which loads MUSMORE automatically), ARITH, ALGEBRA, and LOG, in that order. To solve equations that use logarithmic expressions, you would add to the above the files EQN and SOLVE.

Of course you would like to have all the packages available at once. Unfortunately, due to the large size of the packages, this cannot be done. A 32 K-byte system is necessary to run anything in muMATH-79, but more memory is recommended. It takes 40 K bytes, for example, to run algebra and 48 K bytes to run either calculus or matrix algebra.

A muMATH-79 system is first generated and then saved for future loading into the same system. Each package takes 1 to 5 minutes to load, given a Z80 system running at 4 MHz; loading time will be proportional to the speed of the processor being used.

Another method of loading, called *condensation*, takes from 10 minutes to 1 hour per module to load, but it has the advantage of loading the same module in just over half as much memory. At BYTE Publications Inc, we are running a condensed system in 56 K bytes that includes all the muMATH-79 packages except TRACE, ARRAY, and MATRIX. It took an afternoon to set up the system, but the time was well spent, because all the packages interact with each other. However, problem solution time decreases with increased unused memory. Decreasing the number of packages used would probably cut the solution times of problems, but so far the delays encountered have been hardly objectionable.

The muSIMP-79 Language

An unexpected benefit of the muMATH-79 package is the inclusion of the muSIMP-79 language. muMATH-79 as supplied is actually a series of source files written in muSIMP-79. Inclusion of the source files allows you the very important

MUSIMP79
(+MUSMORE)

TRACE
FOR DEBUGGING MU-SIMP PROGRAMS

ARITH
ARITHMETIC

ARRAY
USED TO BUILD MATRICES

ALGEBRA
MANIPULATION OF EXPRESSIONS USING VARIABLES

MATRIX
MATRIX OPERATIONS—MULTIPLICATION, INVERSION, ETC.

EQN
MANIPULATION OF EQUATIONS

LOG
LOGARITHMIC FUNCTIONS

DIF
DIFFERENTIATION

SOLVE
SOLUTION OF EQUATIONS

TRGPOS
POSITIVE TRIGONOMETRIC FUNCTIONS

TRGNEG
NEGATIVE TRIGONOMETRIC FUNCTIONS

INT
SOLUTION OF INDEFINITE INTEGRALS

INTMORE
MORE COMPLEX INTEGRATION, PLUS DEFINITE INTEGRALS

Figure 2: *Functional dependency chart for the packages in muMATH-79. To run any package shown here, muSIMP-79 and all the packages connecting it to that desired package must be compiled to make a custom muMATH-79 system.*

option of changing or adding to muMATH-79 by changing existing muSIMP-79 programs (ie: packages) or adding your own.

muSIMP-79 is a variation of the well-known list-processing language LISP; it has been adapted for readability and optimized for the manipulation of symbolic expressions. Considering that the entire capabilities of muMATH-79 are based on the use of the muSIMP-79 language, the availability of muSIMP-79 is a definite advantage.

Documentation

The muSIMP/muMATH-79 Symbolic Math System comes with all its associated files on floppy disk and its printed documentation in a three-ring binder. There are about 175 pages of printed documentation in the reference manual, with tabbed sections marked General Information, Calculator-Mode Lessons, Programming-Mode Lessons, muSIMP-79, Arithmetic, Algebra, Equation, Matrix, Log and Trig, and Calculus.

All of the sections consist of either documentation or source code for a particular package, both of which are

available on the disk in machine-readable form. Included are sections on building, saving, and using a muMATH-79 *environment* (which is the muMATH-79 packages compiled plus all the variable and status assignments completed to date). In addition, ten files (five for each subject) that execute interactively on the host computer cover the topics of using muMATH-79 in what is called *calculator mode* and of programming in muSIMP-79.

The Soft Warehouse prints an occasional newsletter that contains updates, additions, and (very occasionally) corrections to its muSIMP/muMATH-79 and muLISP (another of its products) systems. The people at the Soft Warehouse have been friendly and informative every time I've called them.

At a Glance:

Name of program	muSIMP/muMATH-79
Type of program	language/utility
Manufacturer	The Soft Warehouse POB 11174 Honolulu HI 96828 (808) 734-5801
Price	$290
Format	5-inch or 8-inch disk
Language used	8080 machine language
Computer needed	an 8080, 8085, or Z80-based computer running CP/M, CDOS, IMDOS, or TRSDOS operating systems
Documentation	175 pages, 8½ by 11 inches, in three-ring binder
Audience	high-school and college students, educators, programming language enthusiasts

muMATH-79 for the TRS-80

Microsoft Consumer Products of Bellevue, Washington (a sibling company to the Microsoft of Microsoft BASIC fame) is marketing two versions of muSIMP/muMATH-79 for the TRS-80. The first version, equivalent to the one described in this review, will sell for $250.

A slightly diminished version of the system will be available for $75—a very reasonable price. Although I have not seen it, the manufacturer informs us that the system will come with two floppy disks (one for 32 K-byte systems, one for 48 K-byte systems) and an abbreviated manual. The floppy disk for the 32 K-byte system will include muSIMP-79, a precompiled module including the arithmetic, algebra, and equation-solution packages, and uncompiled logarithmic and positive and negative trigonometric packages.

The floppy disk for the 48 K-byte TRS-80 system will be the same but will add the differentiation package and most of the integration packages in the compiled module. Both versions have extensions that allow muSIMP to access the TRS-80 graphics.

Conclusions

- The muSIMP/muMATH-79 Symbolic Math System is a very impressive tool. It fills a gap in the spectrum of problems solvable by a computer.
- Although it cannot work wonders, muSIMP/muMATH-79 *can* solve many of the problems encountered in algebra, trigonometry, and even calculus classes. (Educators need not fear: muMATH-79 does not provide a solution's derivation, only the final answer.)
- Educators from the high-school level up have used the package as an aid to teaching mathematics. And researchers have used it to keep track of equations during complex manipulations. Other potential users include: engineers demanding exact numeric solutions of problems and matrices (the fractional answers can be divided out conventionally to give decimal answers of any accuracy); researchers interested in artificial intelligence; college professors studying programming languages, and all those in need of a calculator.
- Although this is no fault of the package, muMATH-79 occasionally behaves in a way that, although correct, leads to unexpected and seemingly mysterious results. (I, for example, was unable to save a compiled package to disk drive B because I had assigned an algebraic value to the variable B.) Some sophistication on the part of the user is necessary in such cases.
- The documentation is good, but a thorough knowledge of the system is gained only by lots of practical experience. ■

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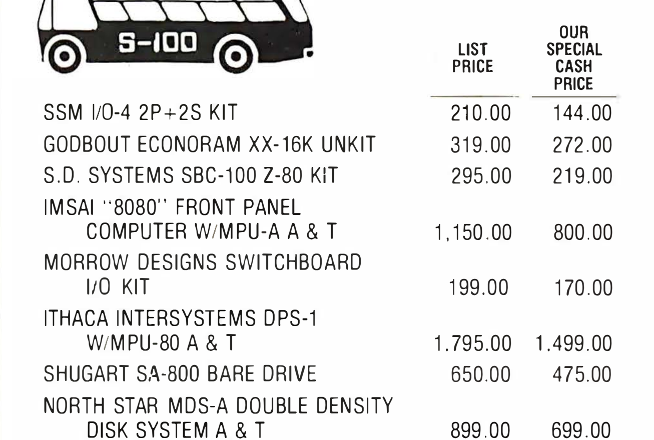
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An 8088 Processor for the S-100 Bus

Part 3

Thomas Woodward Cantrell
2475 Borax Dr
Santa Clara CA 95051

MON88 is a small system monitor for the single-board 8088-based processor described in parts 1 and 2 of this article (September and October 1980 BYTE, pages 43 and 62 respectively).

The current configuration of MON88 implements sixteen commands (expandable to twenty-six) and uses less than 1.5 K bytes of memory. This includes a "large" (approximately 256-byte) video driver required for my hardware environment and lengthy messages (about 128 bytes' worth) that make MON88 easy to use. No attempt was made to optimize the amount of memory used.

Stripping out the video-driver routine (that is, using a hardware *terminal*, rather than software, to create the same effect) and the messages, along with some optimization, can probably reduce code size to 1 K bytes. My plan is to expand the monitor until it fills the 2 K bytes of EPROM (erasable programmable read-only memory) in the 8755A-2 integrated circuit on the processor board. (See table 1 for a quick-reference guide to the MON88 instruction set.)

MON88 Philosophy

The 8088 incorporates very powerful, mainframe-like architectural features such as segmented memory, pipelining, multi- and co-processing "hooks," etc. One key objective of the 8088 project has been to implement the hardware and software in as simple a fashion as possible. This will allow users familiar with traditional 8-bit processors to ease into an understanding of this powerful new machine.

Following the philosophy of simplicity, my 8088 design embodies what is known as the "small model of computation." This model assumes that a given task can be implemented using one set of segmentation register values:

- one 64 K code segment
- one 64 K data segment
- one 64 K stack segment
- one 64 K extra segment

A key feature of the 8088 is that, for many instructions, certain memory segments are used to determine an absolute memory address. This allows instructions to be implemented in fewer bits, contributing to the extremely efficient use of memory in the 8088. This is not a restriction because the default segment can be overridden by using a *segment-prefix* for the instruction in question.

In fact, my decision was to initially use only sixteen of the twenty address lines available on the processor board. In this case, all segments (code, data, stack and extra) totally overlap in the 64 K-byte address space of the processor board. This means we need not concern ourselves with what segment is where, and what instructions assume which segments.

MON88 Organization

The organization of MON88 in memory is shown in figure 1. I will briefly discuss each section. Note that modifications to MON88 for your own environment are discussed later in this article. The following paragraphs describe each section of the monitor.

Storage allocation and constant definition: This section defines commonly used constants and specific I/O (input/output) port addresses, etc. In addition, memory allocation is performed for needed buffer and variable space.

User jump table: This is the first actual code in MON88 consisting of two MON88 entry points (INIT and START) and three I/O entry points (KEYIN, KEYSTAT and VIDOUT). A user program could terminate by jumping to one of the two MON88 entry points. Similarly, a user program could call one of the I/O entry points. When the I/O is done, the return instruction of each I/O routine will give control back to the user program.

Segment register and I/O initialization: The code, data, stack and extra segments (CS, DS, SS and ES) are set overlapping at address 0. Environment-dependent I/O initialization is also performed by this routine.

Main loop: This is the overall control routine for MON88. It prints the prompt character and accepts a one-letter command from the console. The appropriate command-routine address is determined and control is transferred from this routine.

Message storage: Messages used by various commands are stored here. Note that each message is terminated by a 0.

Command jump table: The addresses for the twenty-six possible commands are stored here. Note that

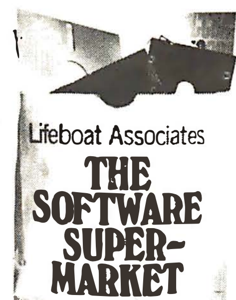
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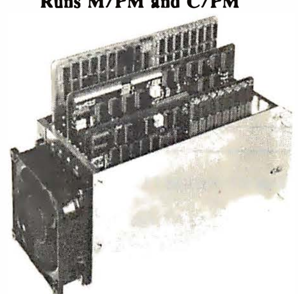


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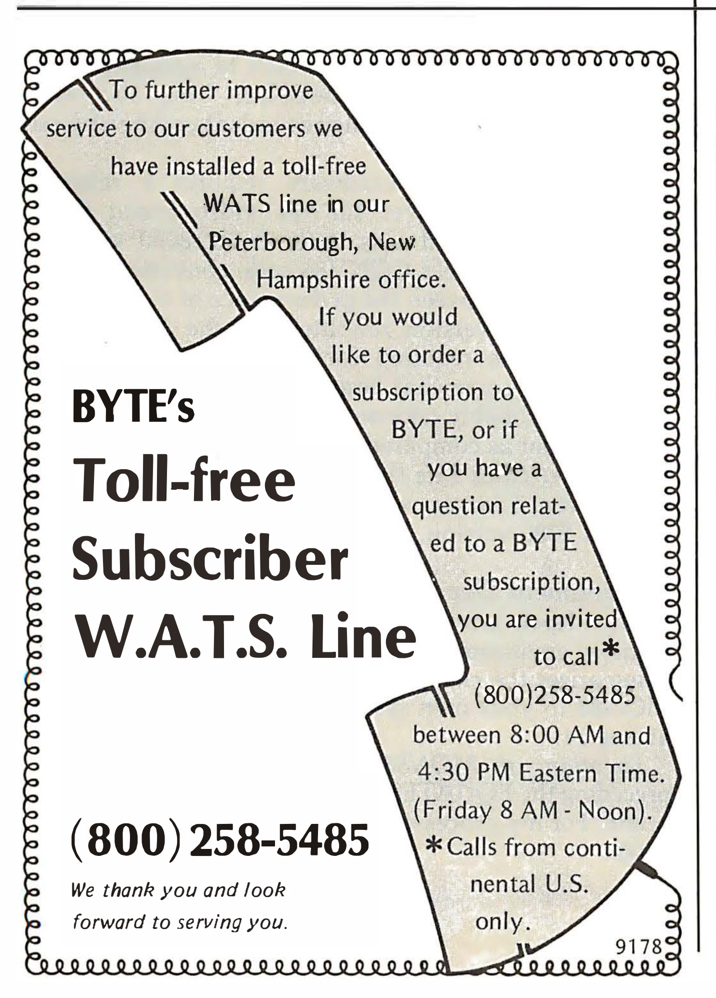
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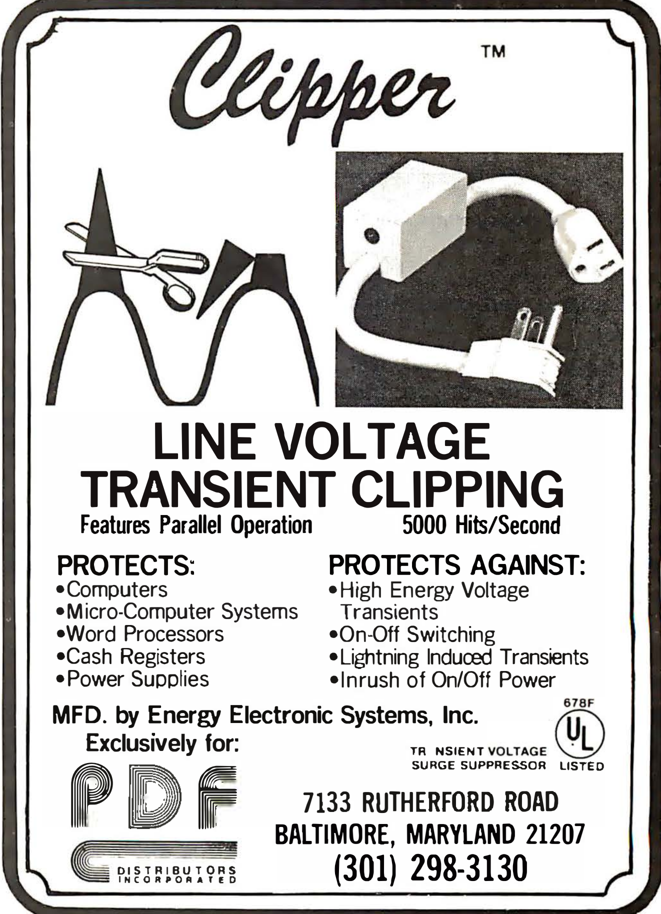
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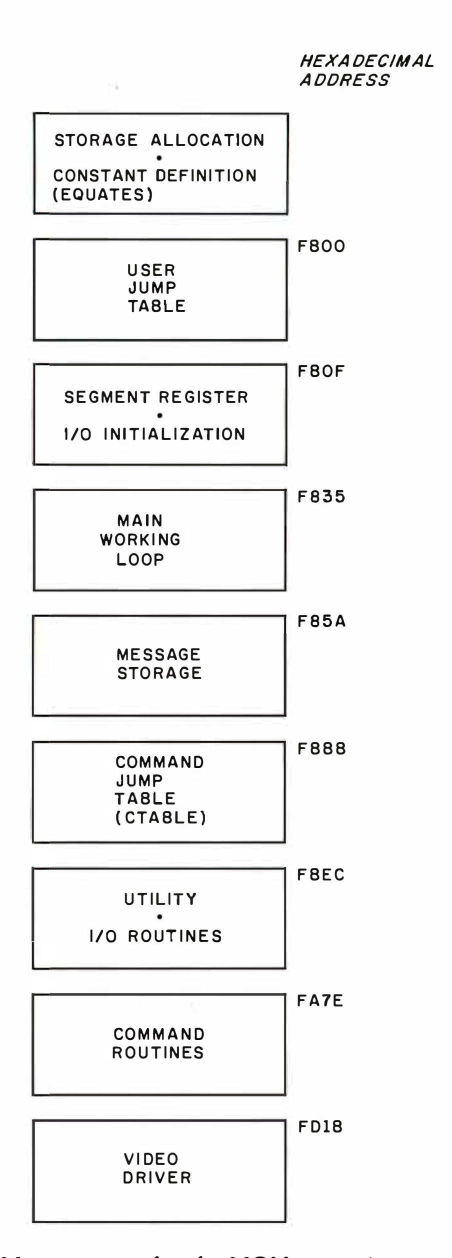


Figure 1: *Memory map for the MON88 monitor.*

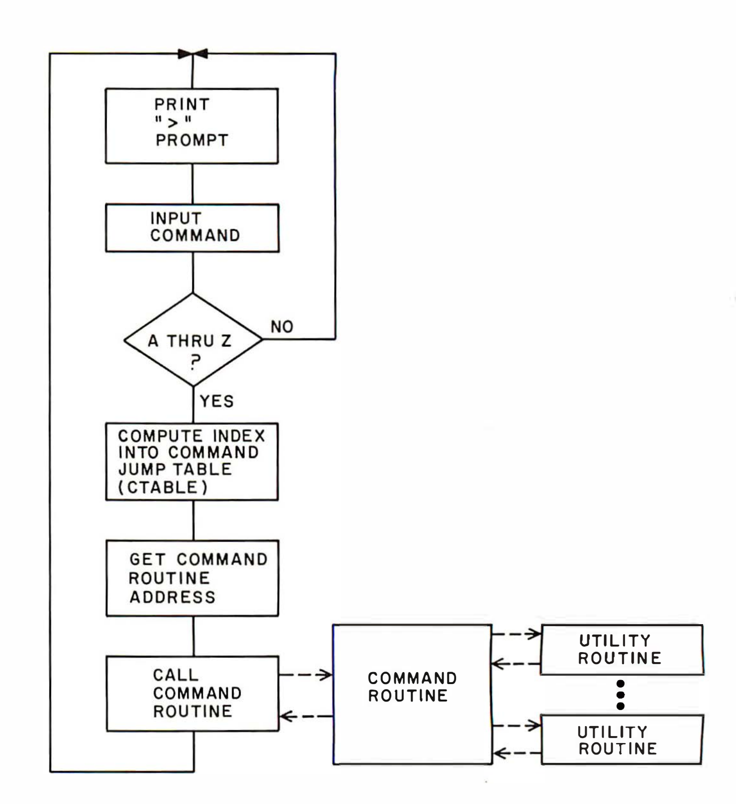


Figure 2: *High-level flowchart for MON88 program. In general, the program decodes user input and, if valid, jumps to the appropriate command subroutine. Once the routine is finished, control is passed back to the command-input routine, and the program prints another prompt.*

unimplemented commands are given the ERR (error) address.

Utility and I/O routines: This and the following (command routines) section make up the bulk of MON88. The utility routines are used by command routines. This allows command routines to be implemented largely as calls to various utility routines (see figure 2). For instance, many commands require the acquisition of a starting and ending address. The utility routine SETUP performs this function. Many of these utility routines may be useful in your own programming efforts.

Command routines: These are the routines that actually perform each command. Due to the extensive use of the above utility routines, most commands are easily implemented as a series of subroutines. A good example is the W (CWRITE) cassette-write command, which dumps a block of memory to tape (see listing 1, starting at line 576). Note that of the twelve "instructions" constituting the command, eight are calls to other routines.

The advantage of programming in this manner is that the command routines are easy to write. Should you want to add commands, they can probably be implemented largely as a series of calls to already-existing, tested utility routines in MON88. This also saves memory space by eliminating redundant coding of essentially the same routine.

Video driver: My hardware requires a relatively lengthy software driver for the video board in my system. I converted this code from 8080 assembly language using Intel's CONV86 code converter. Briefly, the tradeoff is between the performance of the converted code versus a version rewritten for the 8088 and the associated time required for each process. Converted code may be somewhat larger than a rewritten version, but it will probably take only a small fraction of the time to implement as compared to a rewrite. Because the 8088 has a faster clock rate than the 8080, the converted program, even if larger, will probably run faster than the original 8080 version.

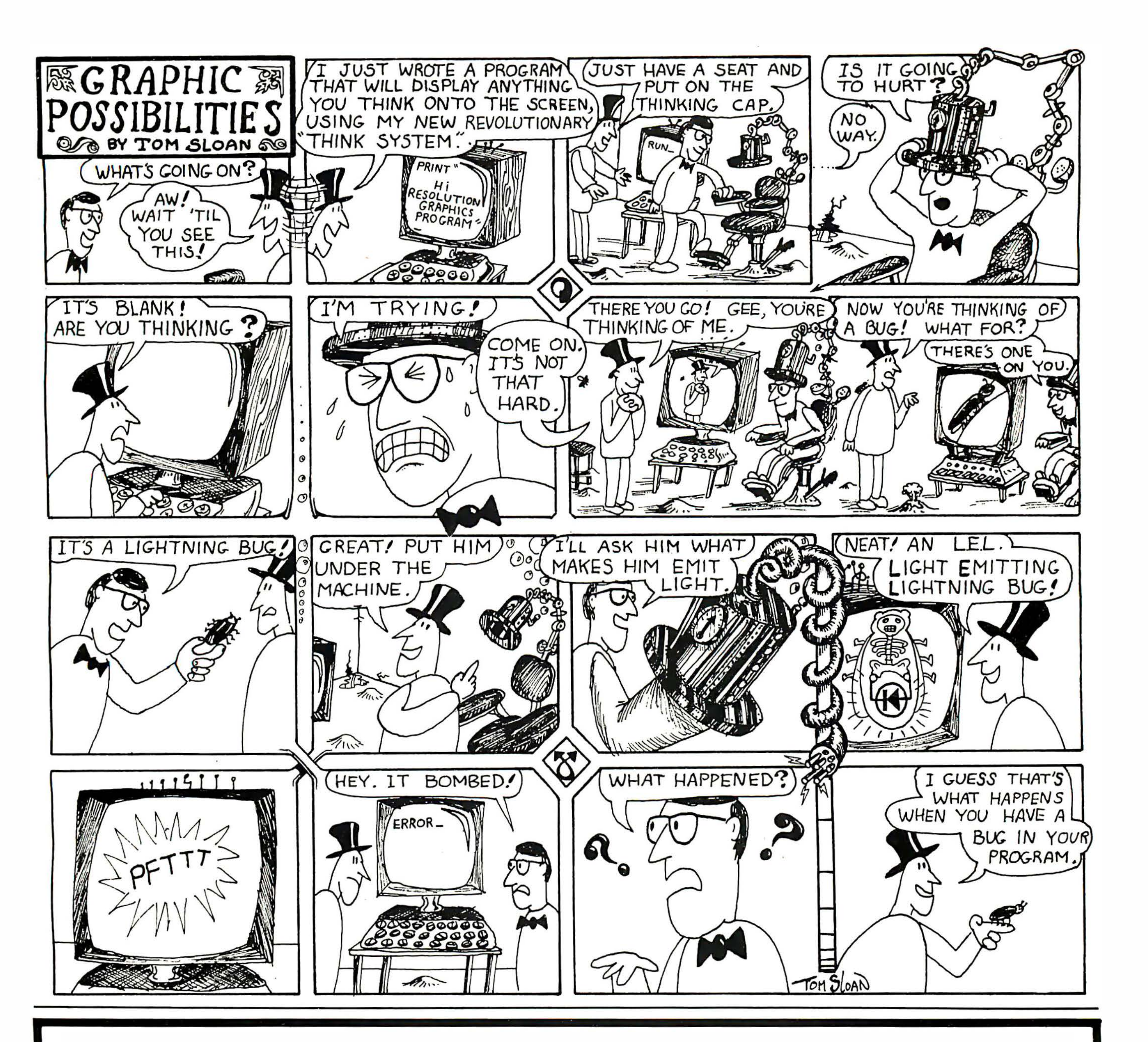
Environment Dependence

The dependence of MON88 on a certain I/O or memory environment has been minimized. The following summarizes the changes you will need to make to adapt MON88 to your own system. Refer to listing 1, starting at line 14.

Location of MON88: The statement immediately preceding the EQUATES FOLLOW section sets MON88's origin. For my processor board, the origin is hexadecimal F800:

```
ORG     F800H
```

Text continued on page 346


GRAPHIC POSSIBILITIES
BY TOM SLOAN
WHAT'S GOING ON?
AW! WAIT 'TIL YOU SEE THIS!
I JUST WROTE A PROGRAM THAT WILL DISPLAY ANYTHING YOU THINK ONTO THE SCREEN, USING MY NEW REVOLUTIONARY "THINK SYSTEM."
PRINT " Hi RESOLUTION GRAPHICS PROGRAM "
JUST HAVE A SEAT AND PUT ON THE THINKING CAP.
RUN_
IS IT GOING TO HURT?
NO WAY.
IT'S BLANK! ARE YOU THINKING?
I'M TRYING!
COME ON. IT'S NOT THAT HARD.
THERE YOU GO! GEE, YOU'RE THINKING OF ME.
NOW YOU'RE THINKING OF A BUG! WHAT FOR?
THERE'S ONE ON YOU.
IT'S A LIGHTNING BUG!
GREAT! PUT HIM UNDER THE MACHINE.
I'LL ASK HIM WHAT MAKES HIM EMIT LIGHT.
NEAT! AN L.E.L.
LIGHT EMITTING LIGHTNING BUG!
PFTTT
HEY. IT BOMBED!
ERROR_
WHAT HAPPENED?
I GUESS THAT'S WHAT HAPPENS WHEN YOU HAVE A BUG IN YOUR PROGRAM.
TOM SLOAN

Command Summary

Command syntax definitions:

[addr] = 16-bit address (or data) as four hexadecimal digits
[data] = 8-bit data as two hexadecimal digits
[cr] = carriage return

Note that [addr] and [data] entry routines accept the last four and two digits entered, respectively. For example, using the fill (F) command:

F0123456 789ABCD 0123456[cr]

is the same as

F3456 ABCD 56[cr]

Also note that [addr], [data] entries to commands can be separated by a blank or a comma, ie:

F3456 ABCD 56[cr]

is the same as

F3456,ABCD,56[cr]

Invalid hexadecimal digits and unimplemented commands always result in an error response. MON88 responds to errors by printing an asterisk (*), carriage return/line feed sequence and redisplaying the prompt.

All entries to MON88 may be either upper or lowercase.

Most commands can be halted temporarily with Control-S, restarted with Control-Q, and aborted with Control-C.

In the following examples, all user input to MON88 is underlined.

Commands

A — Enter ASCII Text into Memory

Allows the direct entry of ASCII text from the keyboard into memory. The command is terminated with a Control-D [ctl-D]. At termination, the address *following* the last character entered is displayed:

```
A[addr][cr]
A100[cr]
This is a test of the 'A' command.[ctl-D]
@0122
D100 121[cr]
0100  54 48 49 53 20 49 53 20 41 20 54 45 53 54 20 4F
0110  46 20 54 48 45 20 27 41 27 20 43 4F 4D 40 41 4E
0120  44 2E
```

B — Not Implemented

C — Compare Cassette Input With Memory

Compares cassette input with the contents of memory on a byte-by-byte basis. All tape-read operations display the length of the file being read when the header is found. In this case the length is hexadecimal 200 bytes. A heading line is displayed, and if a comparison fails, the address and differing inputs are displayed:

```
C[addr][cr]
C100[cr]
ADDR M T  DIFF    LENGTH (HEXADECIMAL)=0200
0102 77   76        00000001
```

In this example, the data coming from tape matched the data located starting at hexadecimal address 100 except for address 102, where a 1-bit error was encountered.

D — Dump or Display the Contents of Memory

Displays the contents of memory from [addr1] to [addr2] as sixteen hexadecimal values per line:

```
D[addr1] [addr2][cr]
D0 20[cr]
0000  01 33 43 56 A3 D8 90 90 34 88 AC EE F0 99 5F 70
0010  86 45 10 3E D4 BB CD EE 42 4E 53 96 9F 88 53 40
0020  74
```

E — Enter Hexadecimal Data From the Keyboard into Memory

After you enter the E command and an address, MON88 will display the current contents of that memory address followed by a "-". The value at that address can be changed by entering a new value. Once a new value has been entered, or if no change to the contents is required, a space is entered. MON88 will then display the contents of the next location followed by a "-". The E command is terminated with a carriage return:

```
E[addr][cr]
D100  104[cr]
0100  01  02  03  05  06
E100[cr]
0100  01-02   02-03   03-04   05-__   06-[cr]
D100  104[cr]
0100  02  03  04  05  06
```

F — Fill a Memory Block With a Constant

Fills a block of memory from [addr1] to [addr2] with a constant value:

```
F[addr1] [addr2] [data][cr]
F100  104  20[cr]
D100  104[cr]
0100  20  20  20  20  20
```

G — Go To and Execute a User Program

MON88 will vector to and begin executing a program in memory. Note that if the user program does not modify the contents of the segment registers, a

return instruction at the end of the program will transfer control to MON88. For this example, note that hexadecimal address F800 is the start address of MON88:

G[addr][cr]
GF800[cr]
(screen clears)
8088 Monitor [rev 0]

H — Compute the Sum and Difference of the 16-Bit Hexadecimal Values

MON88 will compute and display the sum and difference of two 16-bit arguments:

H[addr1] [addr2][cr]
H2000 1010[cr]
SUM DIFF
3010 0FF0

I — Input a Byte From an I/O Port

MON88 will read a byte from an I/O port and display the hexadecimal and binary values. Note that an 8- or 16-bit I/O port address may be specified. If boards in your system decode the upper (A8 thru A15) address lines, use a 16-bit I/O address:

I[addr][cr]

To input from I/O port hexadecimal 20 in the case that *no* I/O boards decode the upper eight address lines:

I20[cr]
23 00100011

To input from I/O port hexadecimal 20 in the case that any I/O boards decode the upper eight address lines for their 8-bit I/O port address:

I2020[cr]
23 00100011

J — Not Implemented

K — Toggle Keyboard Upper/Lower Case

For keyboards with only a "shift lock," the K command will result in teletypewriter-like uppercase capability. In this mode, the letters A thru Z will be automatically shifted to uppercase, while all other keys (ie: the numbers 0 thru 9, etc) will not shift:

K[cr]

L — Not Implemented

M — Move a Block of Memory

This command moves the block of memory between [addr1] and [addr2] (inclusive) to [addr3]. Forward or backward moves are acceptable. Overlapping moves can of course have strange results:

M[addr1] [addr2] [addr3][cr]
D0 F[cr]
0000 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 10
M0 35 [cr]
D0 F [cr]
0000 01 02 03 04 05 01 02 03 04 0A 0B 0C 0D 0E 0F 10

N — Nondestructive Memory Test

A block of memory may be nondestructively tested using a read-complement-write-read-recomplement-compare-write algorithm. This provides a quick check for easily detected failures. Failing bits will be noted in hexadecimal and binary along with the failing address. The memory block will be repeatedly tested until a Control-C is entered:

N[addr1] [addr2][cr]
N0 2000[cr]
12FF 02 00000010
12FF 02 00000010
12FF 02 00000010
.
.
.
[Control-C]

In this case, location hexadecimal 12FF has a bad bit (D1 on a scale of D0 to D7)

O — Output to a Port

This command outputs a byte to an I/O port. As in the Input (I) command, 8- or 16-bit I/O port addresses can be used. The same rule for dealing with S-100 I/O devices that decode their 8-bit I/O address on the upper eight address lines is used:

O[addr] [data][cr]
O2020 FE[cr]

This outputs hexadecimal FE to port hexadecimal 20 (old S-100) or port hexadecimal 2020 (new S-100)

P — Write Continuous Sync Stream to Cassette

A continuous stream of Tarbell format "sync" characters (hexadecimal E6) will be written to tape. The P command is terminated by pressing any key on the keyboard:

P[cr]

Q — Not Implemented

R — Read from Cassette

A file can be read from tape into memory, starting at [addr]. The length of the file is contained in the file header, so no length or ending address input to the R command is required. When MON88 finds the tape header, the file length will be printed on the console, informing the user that loading has been initiated. In this example, the file length is hexadecimal 200 bytes:

R[addr][cr]
R100[cr]
LENGTH (HEXADECIMAL) = 0200

S, T, U — Not Implemented

V — Verify the Equality of Two Blocks of Memory

The block of memory from [addr1] to [addr2] will be compared with the block starting at [addr3]. Differences will be noted in hexadecimal and binary:

```
V[addr1] [addr2] [addr3][cr]
V20 3F 100[cr]
 SRC   M    DEST   M    DIFF
 0022  10   0122   11   00000001
 0030  3E   0130   3F   00000001
```

In this case, the hexadecimal 20 bytes from hexadecimal addresses 20 to 3F are equal to those at address 100 except for two locations: hexadecimal locations 22 and 122 differ, as do locations 30 and 130.

W — Write to Cassette

The block of memory from [addr1] to [addr2] will be written to tape. MON88 will calculate the length of the block, display it, and write it to the tape header for use by the Read ("R") and Compare ("C") commands:

```
W[addr1] [addr2][cr]
W100 1FF[cr]
LENGTH (HEXADECIMAL) = 100
```

The block of memory from hexadecimal 100 to 1FF is written to tape.

X, Y, Z — Not Implemented

Command	Use
A	Enter ASCII text into memory.
B	Not implemented
C	Compare cassette input with memory.
D	Display memory.
E	Enter hexadecimal data into memory.
F	Fill memory with a constant.
G	Go To and execute user program.
H	Hexadecimal math.
I	Input from an I/O port.
J	Not implemented.
K	Toggle keyboard upper/lowercase.
L	Not implemented.
M	Move memory.
N	Nondestructive memory test.
O	Output to an I/O port.
P	Put a continuous 'sync' stream to tape.
Q	Not implemented.
R	Read a file from cassette.
S,T,U	Not implemented.
V	Verify equality of two memory blocks.
W	Write a file to cassette.
X,Y,Z	Not implemented.

Table 1: *A quick reference guide to MON88 commands. Note that only sixteen of the possible twenty-six commands are implemented. While a stripped version of the present monitor can reside in 1 K bytes of memory, there is provision on the processor board for 2 K bytes of EPROM.*

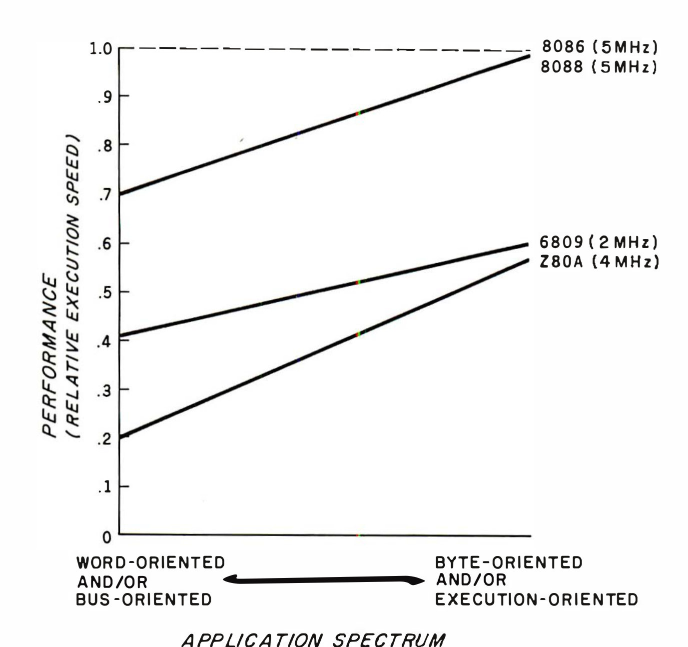


Figure 3: *Relative performance of several 8- and 16-bit microprocessors. The types of programs a processor can run are divided into two groups: those that primarily move data around (word- or bus-oriented) and those that primarily manipulate byte-oriented data or perform many numeric operations. If the 16-bit 8086 microprocessor (dotted line) is defined as a performance figure of 1.0, the other three lines show the approximate relative performance of the three other microprocessors as influenced by the type of program being run.*

Text continued from page 342:

Scratchpad Allocation: My video-board driver uses an 80-byte buffer and a 2-byte X,Y cursor-position variable. These, of course, can be removed or replaced according to your needs. Currently this storage is allocated in the processor boards, 1 K bytes of programmable memory in the (8185-2) device.

The only scratchpad memory required by MON88 is a 1-byte uppercase/lowercase flag variable. This is used by the K (keyboard toggle) command to allow emulation of uppercase-only peripherals in which letters are shifted, but numbers and special characters are not.

If you are not using the processor board described last month and don't have a dedicated scratchpad in the system, UCFLAG can be allocated at the top of memory:

```
UCFLAG    EQU TOPMEM
```

where TOPMEM is the address of the top of memory.

Stack: My stack also resides on the scratchpad memory within the processor board. If you do not have scratchpad, allocate the stack 1 byte below the top of your memory (to leave room for UCFLAG). Note that the stack pointer is decremented before a PUSH operation is performed. Therefore, to allocate the stack 1 byte below the top of memory, set the stack pointer equal to the top of memory:

```
UCFLAG    EQU TOPMEM
STACKP    EQU TOPMEM
```

Listing 1: *Assembly listing of MON88. The flowchart in figure 2 outlines the general operation of the program.*

```
MCS-86 MACRO ASSEMBLER     VID88


ISIS-II MCS-86 MACRO ASSEMBLER V2.0 ASSEMBLY OF MODULE VID88
OBJECT MODULE PLACED IN :F0:VID88.OBJ
ASSEMBLER INVOKED BY:  ASM86 VID88.A86

LOC  OBJ                  LINE     SOURCE

                            1      ;       ******************************************************
                            2      ;       *                                                    *
                            3      ;       *                  M O N 8 8                         *
                            4      ;       *                                                    *
                            5      ;       * A video oriented system monitor for the INTEL 8088 *
                            6      ;       *          written Q1 1980 - revision 0              *
                            7      ;       *          by.. Thomas Woodward Cantrell             *
                            8      ;       *                                                    *
                            9      ;       ******************************************************
                           10      ;
                           11              ASSUME   DS:ABS_0,CS:ABS_0,ES:ABS_0
----                       12      ABS_0   SEGMENT  BYTE AT 0
0000                       13      M       LABEL    BYTE
F800                       14              ORG      0F800H
                           15      ;
                           16      ;       ******************************************************
                           17      ;       *                                                    *
                           18      ;       *               EQUATES FOLLOW                       *
                           19      ;       *                                                    *
                           20      ;       ******************************************************
                           21      ;
  F400                     22      VIDBUF  EQU      0F400H                ;video buffer
  F450                     23      XY      EQU      VIDBUF+80             ;holder for cursor position
  F452                     24      UCFLAG  EQU      XY+2                  ;upper/lower case flag
  000C                     25      FF      EQU      0CH                   ;form feed (clear screen)
  000A                     26      LF      EQU      0AH                   ;line feed
  000D                     27      CR      EQU      0DH                   ;carriage return
  0008                     28      BS      EQU      08H                   ;backspace
```

Listing 1 continued on page 348

where TOPMEM is the address of the top of memory.

Initialization: I/O initialization is done in the INIT section of the monitor (see listing 1, starting at line 76). Starting at hexadecimal F81D, I initialize the Tarbell cassette interface and TDL Video Interface. Replace the section of code from hexadecimal F81D to F828 to suit your I/O needs.

I/O Drivers

MON88 currently uses the following environment-dependent I/O routines (their hexadecimal addresses are given in parentheses):

- KEYIN (F90F)—Reads a byte from the console keyboard, strips off the parity bit, and returns the character in the AL accumulator.
- KEYSTAT (F922)—Reads the console keyboard's status and returns AL=0 if a key has not been pressed and AL = hexadecimal FF if a key has been pressed.
- CIN (F955)—Reads a byte from a mass-storage device (Tarbell cassette, in my case) and returns the byte in the AL accumulator.
- COUT (F964)—Writes the byte contained in the AL accumulator to the mass-storage device.
- CSTART (FB60)—Sets up the mass-storage device for a write operation. For the Tarbell interface, a start byte and a sync byte are required. Replace this code as necessary for your device.
- READINIT (FB9D)—Sets up the mass-storage device for a read operation. Replace the relevant code as necessary.
- PUTSYNC (FBBF)—Outputs a stream of sync bytes to my cassette. This allows calibrating the interface. If your device has a similar feature, modify the PUTSYNC routine accordingly. If not needed, the whole P (PUTSYNC) command can be removed.
- VIDOUT (FCDA)—This routine outputs the character in the AL accumulator to the console display device. In my case, I converted an 8080 version of the video driver to 8088 code using Intel's CONV86 program. Using the code converter, it took only an hour or so to get the driver up and running. I will rewrite it as necessary to reduce the amount of memory used by MON88.

Adding or Removing Commands

All commands are referenced through CTABLE (Command Jump Table) located at hexadecimal F8B8. Note that the commands are arranged in alphabetical order, A thru Z. To remove a command, simply replace its reference in CTABLE with ERR. For example, to remove the K command (uppercase/lowercase toggle), change:

```
F8CC    DW    KTOGGLE
```

to

```
F8CC    DW    ERR
```

then remove the KTOGGLE code (hexadecimal FCD1 to FCD9).

Similarly, to add a special memory test (for example) and call it using the letter T, first write the code (for example, starting label TESTMEM) for the command,

Text continued on page 360

```
E2E2          KSTAT   EQU     0E2E2H                  ;keyboard status port
E3E3          KDATA   EQU     0E3E3H                  ;keyboard data port
6E6E          CSTAT   EQU     6E6EH                   ;Tarbell status port
6F6F          CDATA   EQU     6F6FH                   ;Tarbell data port
F7FF          STACKP  EQU     0F7FFH                  ;Stack address
0003          CTLC    EQU     03H                     ;ascii ctl-c
0004          CTLD    EQU     04H                     ;ascii ctl-d
0013          CTLS    EQU     13H                     ;ascii ctl-s
0011          CTLQ    EQU     11H                     ;ascii ctl-q
0000          FALSE   EQU     0
00FF          TRUE    EQU     0FFH
          +1  $EJECT

MCS-86 MACRO ASSEMBLER     VID88


LOC  OBJ            LINE     SOURCE

                    ;
                    ;       ******************************************************
                    ;       *                                                    *
                    ;       *                  JUMP   TABLE                      *
                    ;       *                                                    *
                    ;       ******************************************************
                    ;
                    ;
F800 EB0D90                 JMP     INIT    ;RESETS STACK, SEGMENT REGISTERS, CASSETTE INTERFACE
                    ;                       ;ALSO PRINTS SIGN-ON MESSAGE
                    ;
F803 EB3090                 JMP     START   ;'WARM START'- REGISTERS NOT INITIALIZED
                    ;
F806 E91901                 JMP     KEYSTAT ;RETURNS [AL]=0 IF NO KEYPRESS PENDING. ELSE [AL]=0FFH
                    ;
F809 E9E000                 JMP     CONIN   ;WAITS FOR KEYPRESS. RETURNS [AL]=CHAR AND PRINTS IT.
                    ;
F80C E9CB04                 JMP     VIDOUT  ;PRINTS CHAR IN AL ON CONSOLE
                    ;
                    ;
                    ;       ******************************************************
                    ;       *                                                    *
                    ;       *          I N I T I A L I Z A T I O N               *
                    ;       *                                                    *
                    ;       ******************************************************
                    ;
                    ;
F80F FC             INIT:   CLD                             ;direction flag points 'up'
F810 FA                     CLI                             ;disable interrupts
F811 8CC8                   MOV     AX,CS                   ;initialize
F813 8ED8                   MOV     DS,AX                   ;   segment
F815 8EC0                   MOV     ES,AX                   ;   registers
F817 8ED0                   MOV     SS,AX                   ;   and set
F819 BCFFF7                 MOV     SP,STACKP               ;  stack pointer
F81C FB                     STI                             ;enable interrupts
F81D B010                   MOV     AL,10H                  ;Reset Cassette
F81F BA6E6E                 MOV     DX,CSTAT
F822 EE                     OUT     DX,AL                   ;   Interface
F823 BAE0E0                 MOV     DX,0E0E0H               ;Reset Video
F826 B088                   MOV     AL,88H                  ;  Interface
F828 EE                     OUT     DX,AL                   ;Inverse video w/cursor
F829 C60652F400             MOV  BYTE PTR M[UCFLAG],0       ;0=lower case, FFH=U/C only

F82E BE5AF890               MOV     SI,OFFSET SIGNON        ;get sign on message
F832 E86301                 CALL    PRINTMESS               ;and print it
                +1  $EJECT

MCS-86 MACRO ASSEMBLER     VID88


LOC  OBJ            LINE     SOURCE

                    ;
                    ;       ******************************************************
                    ;       *                                                    *
                    ;       *            W O R K I N G   L O O P                 *
                    ;       *                                                    *
                    ;       ******************************************************
                    ;
F835 E83D01         START:  CALL    CRLF                    ;print CRLF
F838 B03E                   MOV     AL,'>'                  ;and prompt
F83A E89D04                 CALL    VIDOUT
                    ;
F83D                MAINLOOP:
F83D B400                   MOV     AH,0                    ;clear AH
F83F E8AA00                 CALL    CONIN                   ;get a command
F842 3C41                   CMP     AL,'A'                  ;check range for
F844 72EF                   JB      START                   ;      A
F846 3C5A                   CMP     AL,'Z'                  ;    thru
F848 7FEB                   JG      START                   ;      Z
F84A 2C41                   SUB     AL,'A'                  ;calculate offset
```

```
F84C D0E0             106            SHL     AL,1                    ;and multiply by 2
F84E 05B8F890         107            ADD     AX,OFFSET CTABLE
F852 8BD8             108            MOV     BX,AX
F854 8B07             109            MOV     AX,WORD PTR M[BX]
F856 FFD0             110            CALL    AX                      ;go do it
F858 EBDB             111            JMP     START                   ;start over
                      112 +1    $EJECT


MCS-86 MACRO ASSEMBLER      VID88


LOC  OBJ                   LINE     SOURCE

                      113       ;
                      114       ;        ******************************************
                      115       ;        *                                        *
                      116       ;        *          M E S S A G E S               *
                      117       ;        *                                        *
                      118       ;        ******************************************
                      119       ;
F85A 0C               120       SIGNON  DB      0CH
F85B 38303838204D6F   121               DB      '8088 Monitor <rev. 0>'
     6E69746F72203C
     7265762E20303E
F870 00               122       DBYTE   DB      0                               ;dummy byte
                      123       ;
F871 41444452204D20   124       COMHEAD DB      'ADDR M  T    DIFF
     20542020202044
     494646202020
F885 00               125               DB      0
                      126       ;
F886 53554D20204449   127       MHEAD   DB      'SUM  DIFF'
     4646
F88F 00               128               DB      0
                      129       ;
F890 53524320204D20   130       VHEAD   DB      'SRC  M   DEST M    DIFF'
     20204445535420
     4D202020204449
     4646
F8A7 00               131               DB      0
                      132       ;
F8A8 4C454E47544820   133       CHEAD   DB      'LENGTH (HEX) = '
     2848455829203D
     20
F8B7 00               134               DB      0
                      135       ;
                      136 +1    $EJECT


MCS-86 MACRO ASSEMBLER      VID88


LOC  OBJ                   LINE     SOURCE

                      137       ;
                      138       ;        ************************************************
                      139       ;        *                                              *
                      140       ;        *     C O M M A N D   J U M P   T A B L E      *
                      141       ;        *                                              *
                      142       ;        ************************************************
                      143       ;
F8B8 B0FC             144       CTABLE  DW      AENTER  ;ENTER ASCII TEXT INTO MEMORY
F8BA A7F9             145               DW      ERR     ;B
F8BC D2FB             146               DW      COMPARE ;COMPARE CASSETTE INPUT WITH MEMORY
F8BE 00FB             147               DW      DUMP    ;DISPLAY MEMORY
F8C0 78FC             148               DW      ESUBST  ;ENTER HEX DATA INTO MEMORY
F8C2 7EFA             149               DW      FILL    ;FILL MEMORY WITH A CONSTANT
F8C4 4AFB             150               DW      GOTO    ;GO TO & EXECUTE A USER PROGRAM
F8C6 1AFC             151               DW      HEXMATH ;COMPUTE SUM AND DIFFERENCE OF HEX #'S
F8C8 2CFB             152               DW      INPUT   ;INPUT FROM A PORT
F8CA A7F9             153               DW      ERR     ;J
F8CC D1FC             154               DW      KTOGGLE ;TOGGLE KEYBOARD UPPER/LOWER CASE FLAG
F8CE A7F9             155               DW      ERR     ;L
F8D0 E7FA             156               DW      MOVE    ;MOVE MEMORY
F8D2 3BFC             157               DW      NTEST   ;NON DESTRUCTIVE MEMORY TEST
F8D4 3FFB             158               DW      OUTPUT  ;OUTPUT TO A PORT
F8D6 BFFB             159               DW      PUTSYNC ;OUTPUT CONTINUOUS SYNC STREAM TO CASSETTE
F8D8 A7F9             160               DW      ERR     ;Q
F8DA 82FB             161               DW      READ    ;READ FROM CASSETTE
F8DC A7F9             162               DW      ERR     ;S
F8DE A7F9             163               DW      ERR     ;T
F8E0 A7F9             164               DW      ERR     ;U
F8E2 8DFA             165               DW      VERIFY  ;VERIFY EQUALITY OF TWO MEMORY BLOCKS
F8E4 4FFB             166               DW      CWRITE  ;WRITE TO CASSETTE
F8E6 A7F9             167               DW      ERR     ;X
F8E8 A7F9             168               DW      ERR     ;Y
F8EA A7F9             169               DW      ERR     ;Z
                      170 +1    $EJECT
```

Listing 1 continued on page 350

Listing 1 continued:

```
MCS-86 MACRO ASSEMBLER     VID88


LOC   OBJ                  LINE     SOURCE

                                    ;
                                    ;
                                    ;         **************************************************
                                    ;         *                                                *
                                    ;         *          U T I L I T Y   R O U T I N E S       *
                                    ;         *                        and                     *
                                    ;         *      I / O   D E V I C E   H A N D L E R S     *
                                    ;         *             (except  video  driver)            *
                                    ;         *                                                *
                                    ;         **************************************************
                                    ;
                                    ;
F8EC E82000                         CONIN:    CALL     KEYIN              ;get a keyboard character
F8EF 50                                       PUSH     AX
F8F0 A052F4                                   MOV      AL,BYTE PTR M[UCFLAG]   ;check for case conversion
F8F3 0AC0                                     OR       AL,AL              ;0?
F8F5 7405                                     JZ       CONNEXT            ;YES..no conversion
F8F7 58                                       POP      AX                 ;restore character
F8F8 E80900                                   CALL     UCCHEK             ;convert to UC
F8FB 50                                       PUSH     AX
F8FC 58                             CONNEXT:  POP      AX
F8FD E8DA03                                   CALL     VIDOUT             ;and echo it on console
F900 E80100                                   CALL     UCCHEK             ;always return UC
F903 C3                             KQUIT:    RET
                                    ;
F904 3C61                           UCCHEK:   CMP      AL,'a'
F906 7206                                     JC       UQUIT
F908 3C7B                                     CMP      AL,'z'+1
F90A 7302                                     JNC      UQUIT
F90C 245F                                     AND      AL,5FH
F90E C3                             UQUIT:    RET
                                    ;
F90F 52                             KEYIN:    PUSH     DX                 ;keyboard device handler
F910 BAE2E2                                   MOV      DX,KSTAT
F913 EC                             KEYLOOP:  IN       AL,DX              ;check for keypress
F914 2480                                     AND      AL,80H
F916 74FB                                     JZ       KEYLOOP            ;no keypress..then wait for one
F918 5A                                       POP      DX
F919 52                             KIN:      PUSH     DX
F91A BAE3E3                                   MOV      DX,KDATA
F91D EC                                       IN       AL,DX              ;else get the character
F91E 247F                                     AND      AL,7FH             ;and strip parity
F920 5A                                       POP      DX
F921 C3                                       RET
                                    ;
F922                                KEYSTAT:                              ;RETURN [AL]=0 IF NO KEYPRESS ELSE [AL]=0FFH
F922 B400                                     MOV      AH,FALSE           ;prepare for false
F924 52                                       PUSH     DX
F925 BAE2E2                                   MOV      DX,KSTAT
F928 EC                                       IN       AL,DX
F929 2480                                     AND      AL,80H
F92B 7402                                     JZ       KEXIT              ;return it if no keypress
F92D F6D4                                     NOT      AH                 ;otherwise make it TRUE
F92F 8AC4                           KEXIT:    MOV      AL,AH


MCS-86 MACRO ASSEMBLER     VID88


LOC   OBJ                  LINE     SOURCE

F931 5A                                       POP      DX
F932 C3                                       RET
                                    ;
F933                                CTLCHEK:                              ;CHECK FOR CTL-S, CTL-Q AND CTL-C
F933 50                                       PUSH     AX
F934 E8EBFF                                   CALL     KEYSTAT            ;keypress?
F937 3C00                                     CMP      AL,0
F939 7418                                     JZ       CTLEXIT            ;no keypress so return
F93B E8DBFF                                   CALL     KIN                ;if keypress then get the data
F93E 3C13                                     CMP      AL,CTLS            ;check for ctl-s
F940 750D                                     JNZ      CTLCCHEK           ;if not look for ctl-c
F942 E8CAFF                         KWAIT:    CALL     KEYIN              ;if ctl-s then wait for another keypress
F945 3C11                                     CMP      AL,CTLQ            ;is it ctl-q
F947 740A                                     JZ       CTLEXIT            ;YES..return
F949 3C03                                     CMP      AL,CTLC            ;abort?
F94B 745A                                     JE       ERR                ;YES
F94D EBF3                                     JMP      KWAIT              ;otherwise wait some more
F94F                                CTLCCHEK:
F94F 3C03                                     CMP      AL,CTLC            ;is it ctl-c
F951 7454                                     JZ       ERR                ;YES..ABORT!
F953                                CTLEXIT:
```

```
F953 58                     POP     AX
F954 C3                     RET
                    ;
F955                CIN:                    ;GET BYTE FROM CASSETTE
F955 52                     PUSH    DX
F956 BA6E6E                 MOV     DX,CSTAT
F959                CINLOOP:
F959 EC                     IN      AL,DX
F95A 2410                   AND     AL,10H          ;cassette ready to read?
F95C 75FB                   JNZ     CINLOOP         ;NO..wait
F95E BA6F6F                 MOV     DX,CDATA        ;YES..
F961 EC                     IN      AL,DX           ;get the data
F962 5A                     POP     DX
F963 C3                     RET
                    ;
F964                COUT:                   ;WRITE A BYTE TO CASSETTE
F964 52                     PUSH    DX
F965 50                     PUSH    AX
F966 BA6E6E                 MOV     DX,CSTAT
F969                COUTLOOP:
F969 EC                     IN      AL,DX
F96A 2420                   AND     AL,20H          ;cassette ready for write?
F96C 75FB                   JNZ     COUTLOOP        ;NO..wait
F96E 58                     POP     AX              ;get char back
F96F BA6F6F                 MOV     DX,CDATA
F972 EE                     OUT     DX,AL           ;and send to tape
F973 5A                     POP     DX
F974 C3                     RET
                    ;
F975 50             CRLF:   PUSH    AX
F976 E8BAFF                 CALL    CTLCHEK         ;CHECK FOR ABORT
F979 B00D                   MOV     AL,CR           ;SEND CR AND LF TO CONSOLE
F97B E85C03                 CALL    VIDOUT
```



```
LOC  OBJ            SOURCE

F97E B00A                   MOV     AL,LF
F980 E85703                 CALL    VIDOUT
F983 58                     POP     AX
F984 C3                     RET
                    ;
F985                BLANK:                  ;PRINT A BLANK, SAVE ALL REG.
F985 51                     PUSH    CX
F986 B90100                 MOV     CX,1            ;print 1 blank
F989 E80200                 CALL    TABS
F98C 59                     POP     CX
F98D C3                     RET
                    ;
F98E                TABS:                   ;PRINT # BLANKS IN CX..ON EXIT CX=0
F98E 50                     PUSH    AX
F98F B020                   MOV     AL,' '
F991 E84603         TLOOP:  CALL    VIDOUT
F994 E2FB                   LOOP    TLOOP
F996 58                     POP     AX
F997 C3                     RET
                    ;
F998                PRINTMESS:              ;PRINT THE MESSAGE <-- [SI] ON CONSOLE
F998 50                     PUSH    AX      ;END OF MESSAGE IS A ZERO (0)
F999 AC             PMESS:  LODS    DBYTE           ;get a byte
F99A 3C00                   CMP     AL,0            ;check for end of message
F99C 7407                   JE      PQUIT           ;quit if zero
F99E 56                     PUSH    SI              ;otherwise save message pointer
F99F E83803                 CALL    VIDOUT          ;and display byte
F9A2 5E                     POP     SI
F9A3 EBF4                   JMP     PMESS           ;print more message
F9A5 58             PQUIT:  POP     AX
F9A6 C3                     RET
                    ;
F9A7 B02A           ERR:    MOV     AL,'*'          ;print error
F9A9 E82E03                 CALL    VIDOUT          ;  message
F9AC BCFFF7                 MOV     SP,STACKP       ;reinitialize stack
F9AF E983FE                 JMP     START           ;and abort!
                    ;
F9B2                BINOUT:                         ;OUTPUT [AL] AS EIGHT BINARY DIGITS (BITS)
F9B2 51                     PUSH    CX
F9B3 B90800                 MOV     CX,8
F9B6                BINOUT1:
F9B6 D0E0                   SHL     AL,1            ;get the bit
F9B8 7209                   JB      BOUT1           ;output a 1
F9BA 50                     PUSH    AX              ;otherwise..
F9BB B030                   MOV     AL,'0'          ;output
F9BD E81A03                 CALL    VIDOUT          ;a 0
F9C0 EB0790                 JMP     BINEND          ;continue
F9C3 50             BOUT1:  PUSH    AX
F9C4 B031                   MOV     AL,'1'          ;output a 1
F9C6 E81103                 CALL    VIDOUT
```

Listing 1 continued on page 352

Listing 1 continued:

```
F9C9 58          BINEND: POP     AX
F9CA E2EA                LOOP    BINOUT1          ;do it eight times
F9CC 59                  POP     CX
F9CD C3                  RET

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LOC  OBJ         SOURCE

                 ;
F9CE             HEXOUT:                 ;OUTPUT [AL] AS 2 HEX DIGITS..ALL REG SAVED.
F9CE 50                  PUSH    AX
F9CF 51                  PUSH    CX
F9D0 8AE0                MOV     AH,AL            ;save AL
F9D2 B104                MOV     CL,4
F9D4 D2E8                SHR     AL,CL            ;shift AL right 4 places
F9D6 59                  POP     CX
F9D7 E80700              CALL    HEXDIGOUT        ;output upper nibble
F9DA 8AC4                MOV     AL,AH            ;restore AL (now we do lower nibble)
F9DC E80200              CALL    HEXDIGOUT
F9DF 58                  POP     AX
F9E0 C3                  RET
                 ;
F9E1             HEXDIGOUT:              ;CONVERT NIBBLE TO ASCII HEX
F9E1 240F                AND     AL,0FH           ;mask upper 4 bits
F9E3 0490                ADD     AL,90H           ;tricky conversion...
F9E5 27                  DAA                      ;     but
F9E6 1440                ADC     AL,40H           ;      it
F9E8 27                  DAA                      ;     works!
F9E9 E8EE02              CALL    VIDOUT           ;print the result
F9EC C3                  RET
                 ;
F9ED             HEXCHK:                 ;CHECK AL FOR VALID HEX DIGIT;CONVERT TO BIN
F9ED 2C30                SUB     AL,'0'  ; IF INVALID RETURN WITH CARRY SET.
F9EF 720E                JB      HRET             ;Error..not alphanumeric
F9F1 3C0A                CMP     AL,0AH           ;check for 0-9
F9F3 F5                  CMC
F9F4 7309                JNB     HRET             ;return o.k. if 0-9
F9F6 2C07                SUB     AL,7             ;adjust for A-F
F9F8 3C0A                CMP     AL,10
F9FA 7203                JB      HRET             ;return error if > F
F9FC 3C10                CMP     AL,16
F9FE F5                  CMC
F9FF C3          HRET:   RET
                 ;
FA00             GETPARMB:       ;16 BIT HEX VALUE TO BX. BX IS SHIFT REGISTER, ACCEPTS LAST 4
                                 ;ON ENTRY CX EQUALS NUMBER OF KEYPRESSES THAT CAN BE ACCEPTED.
                                 ;ON EXIT AH CONTAINS TERMINATOR (I.E. CR, SPACE)
                                 ;UNLESS THE TERMINATOR IS INVALID (NOT EQUAL CR, SPACE OR ',')
                                 ; IN WHICH CASE AN ERROR IS GENERATED.
                 ;
FA00 BB0000              MOV     BX,0             ;clear BX
FA03 E8E6FE      LOOPB:  CALL    CONIN            ;get a character
FA06 3C30                CMP     AL,'0'           ;alphanumeric ?
FA08 7210                JB      BEXIT            ;NO...quit
FA0A 51                  PUSH    CX               ;YES...then
FA0B B104                MOV     CL,4             ;shift BX to
FA0D D3E3                SHL     BX,CL            ;make room for
FA0F 59                  POP     CX               ;latest addition
FA10 E8DAFF              CALL    HEXCHK           ;check for valid hex and convert to binary
FA13 7292                JB      ERR              ;if invalid then error!
FA15 02D8                ADD     BL,AL            ;otherwise add it in
FA17 E2EA                LOOP    LOOPB            ;keep looking

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LOC  OBJ         SOURCE

FA19 C3                  RET
FA1A 3C20        BEXIT:  CMP     AL,' '           ;test for blank
FA1C 740B                JE      BGOOD
FA1E 3C2C                CMP     AL,','           ;..comma
FA20 7407                JE      BGOOD
FA22 3C0D                CMP     AL,CR            ; or carriage return
FA24 7403                JE      BGOOD
FA26 E97EFF              JMP     ERR              ;if none of the above the ERROR
FA29 8AE0        BGOOD:  MOV     AH,AL            ;save terminator
FA2B C3                  RET
                 ;
FA2C             GETPARMD:               ;16 BIT HEX VALUE TO DX. USE GETPARMB
FA2C 53                  PUSH    BX               ;save BX
FA2D E8D0FF              CALL    GETPARMB         ;get the parameter
FA30 8BD3                MOV     DX,BX            ;put it where it belongs
FA32 5B                  POP     BX               ;restore BX
FA33 C3                  RET
                 ;
```

```
FA34                   SETUP:                          ;GET PARMS IN BX AND DX. ALL PURPOSE PARAMETER GETTER.
FA34 51                          PUSH     CX                 ;save CX
FA35 B9FFFF                      MOV      CX,0FFFFH          ;allow  64K keypresses
FA38 E8C5FF                      CALL     GETPARMB           ;get first parameter
FA3B 3C0D                        CMP      AL,CR              ;check for carriage return
FA3D 7406                        JE       SET1               ;if so [DX] defaults to [BX]
FA3F E8EAFF                      CALL     GETPARMD           ;otherwise get second parameter
FA42 EB0390                      JMP      SET2
FA45 8BD3              SET1:     MOV      DX,BX
FA47 59                SET2:     POP      CX
FA48 C3                          RET
                       ;
FA49                   CLENGTH:                              ;[CX]<--[DX]-[BX]+1, IF[BX]>[DX] THEN ERR
FA49 52                          PUSH     DX
FA4A 3BD3                        CMP      DX,BX              ;if [BX] > [DX]
FA4C 7303                        JNB      CL1                ;then error!
FA4E E956FF                      JMP      ERR
FA51 2BD3              CL1:      SUB      DX,BX              ;else determine difference
FA53 8BCA                        MOV      CX,DX              ;and put in CX
FA55 41                          INC      CX                 ;count = difference + 1
FA56 5A                          POP      DX
FA57 C3                          RET
                       ;
FA58                   GETPARMAL:                      ;[AL]<-- ASCII HEX FROM CONSOLE
                                                       ;[AL] UNCHANGED IF NO PARAMETER ENTERED
FA58 53                          PUSH     BX                 ;save BX
FA59 51                          PUSH     CX                 ;save CX
FA5A 52                          PUSH     DX                 ;save DX
FA5B 8AD0                        MOV      DL,AL              ;save AL
FA5D B9FFFF                      MOV      CX,0FFFFH          ;64 keypresses allowed
FA60 E89DFF                      CALL     GETPARMB           ;get the parameter
FA63 81F9FFFF                    CMP      CX,0FFFFH          ;how many parameters entered?
FA67 7502                        JNE      GQUIT              ;if greater than zero then continue
FA69 8ADA                        MOV      BL,DL              ;if zero parms entered restore old value
FA6B 8AC3              GQUIT:    MOV      AL,BL              ;otherwise put it where it belongs
FA6D 5A                          POP      DX                 ;restore DX


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LOC  OBJ               LINE      SOURCE

FA6E 59                          POP      CX                 ;restore CX
FA6F 5B                          POP      BX                 ;restore BX
FA70 C3                          RET
                       ;
FA71                   OUTBX:                          ;[BX] OUTPUT AS FOUR HEX DIGITS
FA71 50                          PUSH     AX
FA72 8AC7                        MOV      AL,BH              ;output
FA74 E857FF                      CALL     HEXOUT             ;  BH
FA77 8AC3                        MOV      AL,BL              ;  and
FA79 E852FF                      CALL     HEXOUT             ;  BL
FA7C 58                          POP      AX
FA7D C3                          RET
                       ;
                  +1   $EJECT


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LOC  OBJ               LINE      SOURCE

                       ;
                       ;
                       ;
                       ;
                       ;    ***************************************************
                       ;    *                                                 *
                       ;    *         C O M M A N D   R O U T I N E S         *
                       ;    *                                                 *
                       ;    ***************************************************
                       ;
                       ;
FA7E                   FILL:                           ;FILL A BLOCK OF MEMORY WITH A CONSTANT
FA7E E8B3FF                      CALL     SETUP              ;get start and end
FA81 E8C5FF                      CALL     CLENGTH            ;compute the count
FA84 E8D1FF                      CALL     GETPARMAL          ;and get the constant
FA87 8807              FLOOP:    MOV      M[BX],AL           ;...fill it...
FA89 43                          INC      BX
FA8A E2FB                        LOOP     FLOOP
FA8C C3                          RET
                       ;
FA8D                   VERIFY:                               ;VERIFY EQUALITY OF TWO BLOCKS OF MEMORY
FA8D E8A4FF                      CALL     SETUP              ;GET SOURCE START AND END
FA90 E8B6FF                      CALL     CLENGTH            ;and compute the length
FA93 41                          INC      CX
```

Listing 1 continued on page 354

Listing 1 continued:

```
FA94 8BF3                 MOV     SI,BX            ;save source in SI
FA96 51                   PUSH    CX
FA97 B9FFFF               MOV     CX,OFFFFH        ;64K keypresses allowed
FA9A E863FF               CALL    GETPARMB         ;get the destination
FA9D 59                   POP     CX
FA9E 8BFB                 MOV     DI,BX            ;into DX
FAA0 E8D2FE               CALL    CRLF
FAA3 56                   PUSH    SI               ;save source
FAA4 BE90F8               MOV     SI,OFFSET VHEAD
FAA7 E8EEFE               CALL    PRINTMESS        ;print header
FAAA 5E                   POP     SI               ;restore source
FAAB              VLOOP:
FAAB F3              REPE CMPS    DBYTE,DBYTE      ;do it!
FAAC A6
FAAD 83F900               CMP     CX,0             ;all done?
FAB0 7501                 JNE     VERR             ;NO...error
FAB2 C3                   RET                      ; if done then return
                  ;
FAB3 8BDE         VERR:   MOV     BX,SI            ;get the source addr
FAB5 4B                   DEC     BX               ;adjust it
FAB6 E8BCFE               CALL    CRLF
FAB9 E8B5FF               CALL    OUTBX            ;output the addr
FABC E8C6FE               CALL    BLANK
FABF 8A07                 MOV     AL,M[BX]         ;get what's there
FAC1 8AE0                 MOV     AH,AL            ;save it in AH
FAC3 E808FF               CALL    HEXOUT           ;output the data
FAC6 E8BCFE               CALL    BLANK
FAC9 E8B9FE               CALL    BLANK
FACC 8BDF                 MOV     BX,DI            ;get the destination addr
FACE 4B                   DEC     BX               ;adjust it


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LOC  OBJ          SOURCE

FACF E89FFF               CALL    OUTBX            ;display it
FAD2 8A07                 MOV     AL,M[BX]         ;get the data
FAD4 E8AEFE               CALL    BLANK
FAD7 E8F4FE               CALL    HEXOUT           ;output the data
FADA E8A8FE               CALL    BLANK
FADD 32C4                 XOR     AL,AH            ;determine bad bits
FADF E8D0FE               CALL    BINOUT           ;display in binary
FAE2 E84EFE               CALL    CTLCHEK          ;check for abort
FAE5 EBC4                 JMP     VLOOP            ;continue
                  ;
FAE7              MOVE:                   ;MOVE A BLOCK OF MEMORY
FAE7 E84AFF               CALL    SETUP            ;get start and end
FAEA 3C0D                 CMP     AL,ODH           ;if not enough data
FAEC 7503                 JNZ     M1
FAEE E9B6FE               JMP     ERR              ;then error!
FAF1 E855FF       M1:     CALL    CLENGTH          ;otherwise compute length
FAF4 53                   PUSH    BX               ;save start address
FAF5 E83CFF               CALL    SETUP            ;and get destination
FAF8 8BFB                 MOV     DI,BX            ;[DI] <-- destination
FAFA 5B                   POP     BX
FAFB 8BF3                 MOV     SI,BX            ;[SI] <-- source
FAFD F3            REP    MOVS    DBYTE,DBYTE      ;...move it...
FAFE A4
FAFF C3                   RET
                  ;
FB00              DUMP:                   ;DISPLAY MEMORY
FB00 E831FF               CALL    SETUP            ;get start and end
FB03 E843FF               CALL    CLENGTH          ;and compute length
FB06 E81900               CALL    NULINE2          ;set up console
FB09 8A07         DLOOP1: MOV     AL,M[BX]         ;get what's there
FB0B E8C0FE               CALL    HEXOUT           ;print it
FB0E E874FE               CALL    BLANK            ;and a blank
FB11 43                   INC     BX
FB12 F6C30F               TEST    BL,OFH           ;test for 16 byte boundary
FB15 7503                 JNZ     DNEXT            ;if not then continue
FB17 E80300               CALL    NULINE           ;otherwise set up console for new line
FB1A E2ED         DNEXT:  LOOP    DLOOP1           ;continue
FB1C C3                   RET
                  ;
FB1D 83F901       NULINE: CMP     CX,1
FB20 7409                 JE      NUQUIT
FB22              NULINE2:
FB22 E850FE               CALL    CRLF             ;go to new line
FB25 E849FF               CALL    OUTBX            ;print address
FB28 E85AFE               CALL    BLANK            ;and a blank
FB2B C3           NUQUIT: RET
                  ;
FB2C              INPUT:                  ;INPUT FROM A PORT
FB2C E805FF               CALL    SETUP            ;get port address
FB2F E843FE               CALL    CRLF
FB32 8BD3                 MOV     DX,BX
FB34 EC                   IN      AL,DX            ;read the port
FB35 E896FE               CALL    HEXOUT           ;print data in hex
FB38 E84AFE               CALL    BLANK            ;      and
```

```
LOC   OBJ           SOURCE

FB3B E874FE                    CALL    BINOUT          ;     binary
FB3E C3                        RET
                    ;
FB3F                OUTPUT:                    ;OUTPUT TO A PORT
FB3F E8F2FE                    CALL    SETUP           ;get address
FB42 8AC2                      MOV     AL,DL           ;and data
FB44 FEC8                      DEC     AL              ;adjust data
FB46 8BD3                      MOV     DX,BX
FB48 EE                        OUT     DX,AL           ;output data
FB49 C3                        RET
                    ;
FB4A                GOTO:                      ;EXECUTE A PROGRAM
FB4A E8E7FE                    CALL    SETUP           ;get the address
FB4D FFE3                      JMP     BX              ;GO!!
                    ;
FB4F                CWRITE:                    ;WRITE TO CASSETTE
FB4F E8E2FE                    CALL    SETUP           ;get the range
FB52 E8F4FE                    CALL    CLENGTH         ;compute the length
FB55 E81DFE                    CALL    CRLF
FB58 E85500                    CALL    CPROMPT
FB5B E80F00                    CALL    CSTART
FB5E E85600                    CALL    LENGTHOUT       ;tell length
FB61 8A07           CLOOP:     MOV     AL,M[BX]        ;get a byte
FB63 E8FEFD                    CALL    COUT            ;output
FB66 43                        INC     BX              ;next byte
FB67 E8C9FD                    CALL    CTLCHEK         ;check for abort
FB6A E2F5                      LOOP    CLOOP           ;continue
FB6C C3                        RET
                    ;
FB6D B03C           CSTART:    MOV     AL,3CH          ;start byte
FB6F E8F2FD                    CALL    COUT
FB72 B0E6                      MOV     AL,0E6H         ;sync byte
FB74 E8EDFD                    CALL    COUT
FB77 8AC5                      MOV     AL,CH           ;high length
FB79 E8E8FD                    CALL    COUT
FB7C 8AC1                      MOV     AL,CL           ;low length
FB7E E8E3FD                    CALL    COUT
FB81 C3                        RET
                    ;
FB82                READ:                      ;READ FROM CASSETTE
FB82 E8AFFE                    CALL    SETUP           ;get address
FB85 E8EDFD                    CALL    CRLF
FB88 E82500                    CALL    CPROMPT
FB8B E80F00                    CALL    READINIT
FB8E E82600                    CALL    LENGTHOUT       ;prompt when reading
FB91 E8C1FD         RLOOP:     CALL    CIN             ;get a byte
FB94 8807                      MOV     M[BX],AL
FB96 43                        INC     BX              ;next byte
FB97 E899FD                    CALL    CTLCHEK         ;check for abort
FB9A E2F5                      LOOP    RLOOP           ;continue
FB9C C3                        RET
                    ;
FB9D                READINIT:
FB9D B010                      MOV     AL,10H          ;reset interface
```



```
LOC   OBJ           SOURCE

FB9F 52                        PUSH    DX
FBA0 BA6E6E                    MOV     DX,CSTAT
FBA3 EE                        OUT     DX,AL
FBA4 5A                        POP     DX
FBA5 E8ADFD                    CALL    CIN
FBA8 8AE8                      MOV     CH,AL           ;get high length
FBAA E8A8FD                    CALL    CIN
FBAD 8AC8                      MOV     CL,AL           ;and low length
FBAF C3                        RET
                    ;
FBB0                CPROMPT:                   ;CASSETTE PROMPT
FBB0 BEA8F8                    MOV     SI, OFFSET CHEAD
FBB3 E8E2FD                    CALL    PRINTMESS
FBB6 C3                        RET
                    ;
FBB7                LENGTHOUT:                 ;OUTPUT RECORD LENGTH
FBB7 53                        PUSH    BX
FBB8 8BD9                      MOV     BX,CX           ;get the count
FBBA E8B4FE                    CALL    OUTBX           ;output it
FBBD 5B                        POP     BX
FBBE C3                        RET
```

Listing 1 continued on page 356

Listing 1 continued:

```
                ;
FBBF            PUTSYNC:                        ;SEND SYNC STREAM TO CASSETTE
FBBF E8B3FD             CALL    CRLF
FBC2            SYNCLOOP:
FBC2 B0E6               MOV     AL,0E6H         ;sync character
FBC4 E89DFD             CALL    COUT            ;send it
FBC7 E858FD             CALL    KEYSTAT         ;check for keypress
FBCA 3C00               CMP     AL,0            ;zero = no keypress
FBCC 74F4               JE      SYNCLOOP        ;so continue
FBCE E848FD             CALL    KIN             ;ignore the keypress
FBD1 C3                 RET                     ;and quit
                ;
FBD2            COMPARE:                        ;COMPARE INPUT FROM CASSETTE WITH MEMORY
FBD2 E85FFE             CALL    SETUP
FBD5 E89DFD             CALL    CRLF
FBD8 BE71F8             MOV     SI, OFFSET COMHEAD      ;print header
FBDB E8BAFD             CALL    PRINTMESS
FBDE E8A4FD             CALL    BLANK
FBE1 E8CCFF             CALL    CPROMPT
FBE4 E8B6FF             CALL    READINIT
FBE7 E8CDFF             CALL    LENGTHOUT
FBEA            COMLOOP:
FBEA E868FD             CALL    CIN             ;get char from cassette
FBED 3A07               CMP     AL,M[BX]        ;compare with memory
FBEF 7507               JNE     COMERR          ;not equal!! error
FBF1 43         COM1:   INC     BX              ;if equal
FBF2 E83EFD             CALL    CTLCHEK         ;check for abort
FBF5 E2F3               LOOP    COMLOOP         ;then continue checking
FBF7 C3                 RET
FBF8 50         COMERR: PUSH    AX
FBF9 E879FD             CALL    CRLF
FBFC E872FE             CALL    OUTBX           ;if error..output memory address
FBFF E883FD             CALL    BLANK
```

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```
LOC  OBJ        SOURCE

FC02 8A07               MOV     AL,M[BX]        ;get memory data
FC04 8AF0               MOV     DH,AL           ;save it too
FC06 E8C5FD             CALL    HEXOUT          ;output what's in memory
FC09 E879FD             CALL    BLANK
FC0C 58                 POP     AX              ;restore cassette data
FC0D E8BEFD             CALL    HEXOUT          ;output it
FC10 E872FD             CALL    BLANK
FC13 32C6               XOR     AL,DH           ;determine bad bits
FC15 E89AFD             CALL    BINOUT          ;and print in binary
FC18 EBD7               JMP     COM1            ;continue
                ;
FC1A            HEXMATH:                        ;COMPUTE SUM AND DIFFERENCE OF TWO HEX #'S
FC1A E817FE             CALL    SETUP           ;get the numbers
FC1D 53                 PUSH    BX              ;save
FC1E 52                 PUSH    DX              ; them
FC1F E853FD             CALL    CRLF
FC22 BE86F8             MOV     SI, OFFSET MHEAD
FC25 E870FD             CALL    PRINTMESS       ;print the header
FC28 E84AFD             CALL    CRLF
FC2B 03DA               ADD     BX,DX           ;sum
FC2D E841FE             CALL    OUTBX
FC30 E852FD             CALL    BLANK
FC33 5A                 POP     DX              ;restore
FC34 5B                 POP     BX              ; numbers
FC35 2BDA               SUB     BX,DX           ;difference
FC37 E837FE             CALL    OUTBX
FC3A C3                 RET
                ;
FC3B            NTEST:                  ;MEMORY TEST
FC3B E8F6FD             CALL    SETUP           ;get start and end
FC3E E808FE             CALL    CLENGTH         ;compute length
FC41 E831FD             CALL    CRLF
FC44 53         MTEST1: PUSH    BX
FC45 51                 PUSH    CX
FC46 8A07       MTLOOP: MOV     AL,M[BX]        ;get what's there
FC48 8AE0               MOV     AH,AL           ;save it
FC4A F6D0               NOT     AL              ;complement
FC4C 8807               MOV     M[BX],AL        ;and store it back
FC4E 8A07               MOV     AL,M[BX]        ;read it again
FC50 F6D0               NOT     AL              ;re-complement
FC52 3AC4               CMP     AL,AH           ;is it o.k.?
FC54 750C               JNE     SHORT   TERR    ;if not then error!
FC56 8827               MOV     M[BX],AH        ;restore previous value
FC58 43         TNEXT:  INC     BX              ;next location
FC59 E8D7FC             CALL    CTLCHEK         ;check for abort
FC5C E2E8               LOOP    MTLOOP          ;continue
FC5E 59                 POP     CX
FC5F 5B                 POP     BX
FC60 EBE2               JMP     MTEST1          ;test forever
                ;
```

```
FC62 E810FD                719    TERR:     CALL    CRLF              ;TELL USER ABOUT BAD MEMORY
FC65 E809FE                720              CALL    OUTBX             ;output bad address
FC68 E81AFD                721              CALL    BLANK             ;and a blank
FC6B 32C4                  722              XOR     AL,AH             ;tell user which

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LOC  OBJ                   LINE     SOURCE

FC6D E85EFD                723              CALL    HEXOUT            ;bits are bad in hex...
FC70 E812FD                724              CALL    BLANK
FC73 E83CFD                725              CALL    BINOUT            ;and binary
FC76 EBE0                  726              JMP     TNEXT             ; continue
                           727    ;
FC78                       728    ESUBST:                      ;SUBSTITUTE MEMORY WITH HEX DATA
FC78 E8B9FD                729              CALL    SETUP             ;get address
FC7B                       730    NUSLOOP:
FC7B E8F7FC                731              CALL    CRLF              ;and
FC7E E8F0FD                732              CALL    OUTBX             ;print it
FC81 B90800                733              MOV     CX,8              ;8 entries per line
FC84 E8FEFC                734    SLOOP:    CALL    BLANK
FC87 8A07                  735              MOV     AL,M[BX]          ;get what's there
FC89 E842FD                736              CALL    HEXOUT            ;and print it
FC8C 50                    737              PUSH    AX                ;save it
FC8D B02D                  738              MOV     AL,'-'            ;with a prompt
FC8F E84800                739              CALL    VIDOUT
FC92 58                    740              POP     AX                ;restore it
FC93 E8C2FD                741              CALL    GETPARMAL         ;get new data
FC96 E90890                742              JMP     QTEST             ;check for quit
FC99 8807                  743    SNEXT:    MOV     M[BX],AL          ;otherwise, put new data in memory
FC9B 43                    744              INC     BX                ;and continue
FC9C E2E6                  745              LOOP    SLOOP
FC9E EBDB                  746              JMP     NUSLOOP
FCA0 80FC20                747    QTEST:    CMP     AH,' '            ;if blank then
FCA3 74F4                  748              JE      SNEXT             ;continue
FCA5 80FC0D                749              CMP     AH,0DH            ;if carraige return
FCA8 7403                  750              JE      Q1                ;then we are done
FCAA E9FAFC                751              JMP     ERR               ;otherwise..error!
FCAD 8807                  752    Q1:       MOV     M[BX],AL          ;save that last one!
FCAF C3                    753              RET
                           754    ;
FCB0                       755    AENTER:                             ;ENTER ASCII TEXT IN MEMORY
FCB0 B9FFFF                756              MOV     CX,0FFFFH         ;64K keypresses
FCB3 E84AFD                757              CALL    GETPARMB          ;get the entry address
FCB6 E8BCFC                758              CALL    CRLF
FCB9 E830FC                759    ELOOP:    CALL    CONIN
FCBC 3C04                  760              CMP     AL,CTLD           ;done?
FCBE 7405                  761              JE      EEXIT             ;YES
FCC0 8807                  762              MOV     M[BX],AL          ;NO..put data in memory
FCC2 43                    763              INC     BX
FCC3 EBF4                  764              JMP     ELOOP
FCC5 E8ADFC                765    EEXIT:    CALL    CRLF
FCC8 B040                  766              MOV     AL,'@'
FCCA E80D00                767              CALL    VIDOUT
FCCD E8A1FD                768              CALL    OUTBX             ;output the ending address
FCD0 C3                    769              RET
                           770    ;
FCD1                       771    KTOGGLE:                         ;TOGGLE THE UPPER/LOWER CASE FLAG
FCD1 A052F4                772              MOV     AL,BYTE PTR M[UCFLAG]   ;get the flag
FCD4 F6D0                  773              NOT     AL                      ;toggle
FCD6 A252F4                774              MOV     BYTE PTR M[UCFLAG],AL   ;put flag back
FCD9 C3                    775              RET
                           776    ;

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LOC  OBJ                   LINE     SOURCE

                           777 +1   $EJECT


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LOC  OBJ                   LINE     SOURCE

                           778    ;
                           779    ;
                           780    ;
                           781    ;         ****************************************************
                           782    ;         *                                                  *
                           783    ;         *           V I D E O   D R I V E R                *
                           784    ;         *                                                  *
```

Listing 1 continued on page 358

Listing 1 continued:

```
                   ;          *                                                      *
                   ;          *        DRIVES  TDL  VDB  VIDEO  INTERFACE            *
                   ;          *                                                      *
                   ;          *    converted from 8080 Assembler with CONV-86        *
                   ;          *                                                      *
                   ;          ********************************************************
                   ;
                   ;
                   ;          VIDEO DRIVER
                   ;
FCDA 50            VIDOUT:    PUSH    AX
FCDB 56                       PUSH    SI
FCDC 57                       PUSH    DI
FCDD E80400                   CALL    VIDEO
FCE0 5F                       POP     DI
FCE1 5E                       POP     SI
FCE2 58                       POP     AX
FCE3 C3                       RET
                   ;
                   ;******** CONVERTED CODE BEGINS HERE ********
                   ;
                   ;VDB DRIVER
  00E1             VD         EQU     0E1H
  00E0             VC         EQU     0E0H
  00E0             XRD        EQU     0E0H
  00E1             YRD        EQU     0E1H
  00C0             YWR        EQU     0C0H
  00E2             MRD        EQU     0E2H
  0080             MWR        EQU     80H
  0088             VMODE      EQU     88H
  0098             BMODE      EQU     98H
                   ;
                   ;
FCE4 53            VIDEO:     PUSH    BX
FCE5 8B1E50F4                 MOV     BX,WORD PTR M[XY]
FCE9 247F                     AND     AL,7FH
FCEB 7403                     JZ      SHORT L_2
FCED E80600                   CALL    VOUT
FCF0               L_2:
FCF0 891E50F4                 MOV     WORD PTR M[XY],BX
FCF4 5B                       POP     BX
FCF5 C3                       RET
                   ;
FCF6 3C20          VOUT:      CMP     AL,20H
FCF8 7303                     JAE     SHORT L_3
FCFA EB7490                   JMP     CNTL
FCFD               L_3:
```

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```
LOC  OBJ           LINE    SOURCE

FCFD 3C7F                     CMP     AL,7FH
FCFF 7501                     JNZ     SHORT L_4
FD01 C3                       RET
FD02               L_4:
FD02 E6E1                     OUT     VD,AL
FD04 FECF                     DEC     BH
FD06 7401                     JZ      SHORT L_5
FD08 C3                       RET
FD09               L_5:
FD09 B750                     MOV     BH,80
FD0B FECB                     DEC     BL
FD0D 7401                     JZ      SHORT L_6
FD0F C3                       RET
FD10               L_6:
FD10 FEC3          V02:       INC     BL
                   ;
FD12 53            SCROLL:    PUSH    BX
FD13 52                       PUSH    DX
FD14 51                       PUSH    CX
FD15 B098                     MOV     AL,BMODE
FD17 E6E0                     OUT     VC,AL
FD19 32C0                     XOR     AL,AL
FD1B E6E0                     OUT     VC,AL
FD1D BA50C1                   MOV     DX,0C150H
FD20 8AC6                     MOV     AL,DH
FD22 E6E0          S1:        OUT     VC,AL
FD24 8AEA                     MOV     CH,DL
FD26 BB00F4                   MOV     BX,VIDBUF
FD29 E4E1          L1:        IN      AL,VD
FD2B 8807                     MOV     M[BX],AL
FD2D 9F                       LAHF
FD2E 43                       INC     BX
FD2F 9E                       SAHF
FD30 FECD                     DEC     CH
FD32 75F5                     JNZ     L1
FD34 8AC6                     MOV     AL,DH
```

```
FD36 FEC8         868                DEC    AL
FD38 E6E0         869                OUT    VC, AL
FD3A BB00F4       870                MOV    BX, VIDBUF
FD3D 8AEA         871                MOV    CH, DL
FD3F 8A07         872       L2:      MOV    AL, M[BX]
FD41 E6E1         873                OUT    VD, AL
FD43 9F           874                LAHF
FD44 43           875                INC    BX
FD45 9E           876                SAHF
FD46 FECD         877                DEC    CH
FD48 75F5         878                JNZ    L2
FD4A FEC6         879                INC    DH
FD4C 8AC6         880                MOV    AL, DH
FD4E 3CD9         881                CMP    AL, 0D9H
FD50 72D0         882                JB     S1
FD52 8AEA         883                MOV    CH, DL
FD54 B020         884                MOV    AL, 20H
FD56 E6E1         885       S2:      OUT    VD, AL

MCS-86 MACRO ASSEMBLER      VID88

LOC  OBJ          LINE      SOURCE

FD58 FECD         886                DEC    CH
FD5A 75FA         887                JNZ    S2
FD5C 59           888                POP    CX
FD5D 5A           889                POP    DX
FD5E 5B           890                POP    BX
FD5F B088         891       SETCAV:  MOV    AL, VMODE
FD61 E6E0         892                OUT    VC, AL
FD63 B050         893       SETCUR:  MOV    AL, 80
FD65 2AC7         894                SUB    AL, BH
FD67 E6E0         895                OUT    VC, AL
FD69 B0D9         896                MOV    AL, 25+0C0H
FD6B 2AC3         897                SUB    AL, BL
FD6D E6E0         898                OUT    VC, AL
FD6F C3           899                RET
                  900       ;
FD70 3C0D         901       CNTL:    CMP    AL, CR
FD72 7422         902                JZ     SHORT CCR
FD74 3C0A         903                CMP    AL, LF
FD76 7415         904                JZ     SHORT CLF
FD78 3C0C         905                CMP    AL, FF
FD7A 741E         906                JZ     SHORT CFF
FD7C 3C08         907                CMP    AL, BS
FD7E 7401         908                JZ     SHORT CBS
FD80 C3           909                RET
FD81 B04F         910       CBS:     MOV    AL, 79
FD83 2AC7         911                SUB    AL, BH
FD85 7901         912                JNS    SHORT L_8
FD87 C3           913                RET
FD88              914       L_8:
FD88 E6E0         915                OUT    VC, AL
FD8A FEC7         916                INC    BH
FD8C C3           917                RET
FD8D FECB         918       CLF:     DEC    BL
FD8F 7503         919                JNZ    SHORT L_9
FD91 E97CFF       920                JMP    V02
FD94              921       L_9:
FD94 EBCD         922                JMP    SETCUR
FD96 B750         923       CCR:     MOV    BH, 80
FD98 EBC9         924                JMP    SETCUR
FD9A B098         925       CFF:     MOV    AL, BMODE
FD9C E6E0         926                OUT    VC, AL
FD9E BBD007       927                MOV    BX, 25*80
FDA1 32C0         928       CFF1:    XOR    AL, AL
FDA3 E6E1         929                OUT    VD, AL
FDA5 9F           930                LAHF
FDA6 4B           931                DEC    BX
FDA7 9E           932                SAHF
FDA8 8AC7         933                MOV    AL, BH
FDAA 0AC3         934                OR     AL, BL
FDAC 75F3         935                JNZ    CFF1
FDAE BB1950       936                MOV    BX, 256*80+25
FDB1 EBAC         937                JMP    SETCAV
                  938       ;
----              939       ABS_0    ENDS


MCS-86 MACRO ASSEMBLER      VID88


LOC  OBJ               LINE      SOURCE

  F80F                 940              END      INIT

ASSEMBLY COMPLETE, NO ERRORS FOUND
```

Text continued from page 347:
followed by a RET (return) statement. Then replace:

```
        F8DE    DW    ERR
```

with

```
        F8DE    DW    TESTMEM
```

Notes on Performance

How does the 8088 stack up in performance versus the popular 8-bit processors of the 1970s? To answer this question, we must develop at least a rough definition of what we mean by performance.

To evaluate performance I use three criteria:

- the execution speed for a set of applications,
- the amount of memory required to implement the applications, and
- the amount of software-development effort required for application implementation (as measured by lines of assembly-language code).

An appropriate set of applications will include a mix of mathematics, data-handling and process-control-type programs. In addition, both execution-bound (eg: heavy calculation) and bus-bound (eg: bubble sort) applications should be included.

This article is not meant to be a full-fledged benchmark report. Nevertheless, using my own background, manufacturer's documentation, and other sources, I have come to the following conclusions concerning the 5 MHz 8088, which on the average:

- is 1.5 to 5 times faster than the *fastest* versions of other popular 8-bit machines (ie: Z80B, 68B09, 6800, 8080A, etc),
- will typically require only 50% to 75% of the memory devoted to code by these other machines for a set of applications, and
- requires substantially less (as little as 50% or less) lines of code to implement a benchmark than these other machines.

Execution speed is the most visible measure of performance. Factors which contribute to the 8088's superiority are:

- *The high standard clock rate:* The standard 8088 runs at 5 MHz (in fact, possibly faster if you're willing to experiment). Intel claims that, next year, specially selected 8 MHz 8088s will be available. If 5 MHz 8088s are fast, 8 MHz 8088s will be *unreal.*
- *The pipelined architecture:* This architecture allows overlapped instruction fetch and execution, eliminating a traditional performance limitation present in other 8-bit machines.
- *The 16-bit internal data paths:* These enhance data movement and manipulation capability.
- *Its rich set of arithmetic instructions:* Math-oriented applications are served exceptionally well by the 8088. The 5 MHz 8088 can do most 16-bit integer math (add, subtract, multiply, divide) faster than a 9511 hardware math chip.
- *Powerful addressing modes:* The 8088 allows up to four address components to be used in calculating an absolute physical memory address. In addition, most instructions can operate *directly on a memory location,* eliminating the traditional accumulator bottlenck found in other machines.

The amount of memory required can have significant cost ramifications for an application. Here again, the 16-bit internal organization and powerful addressing modes of the 8088 reduce memory requirements. In extreme cases (heavily word- or math-oriented) the 8088 can implement applications in as little as 20% to 30% of the memory of other 8-bit machines.

The number of lines of code required to implement an application becomes more and more of an issue each day. For instance, the Department of Defense states that one line of debugged, documented code now costs close to $60. Programming costs continue to rise, while productivity remains relatively fixed. This suggests a real "software crisis" in the 1980s.

The 8088 can require as little as 50% (average perhaps 75%) of the lines of code as compared to other 8-bit machines. This is because one assembly-language instruction can generate up to 6 bytes of code, and the instructions implemented are very powerful relative to other popular microprocessors.

A summary chart of my findings is shown in figure 3. The relative performance of the 8088 (5 MHz), 6809 (2 MHz) and Z80A (4 MHz) are shown, with an 8086 (true 16-bit machine) thrown in for reference. A differentiation between *word-* or *bus-*oriented and *byte-* or *execution-*oriented applications must be made here. Note that the bus-oriented versus execution-oriented differentiation does not apply to nonpipelined machines like the Z80A or 6809. The byte-orientation versus word-orientation differentiation *does* affect the performance of these machines.

Full-speed memories are assumed as shown below:

	Processor	*Access Time (approximately)*
5 MHz	8088, 8086	480 ns
2 MHz	6809	320 ns
4 MHz	Z80A	250 ns

As shown above, the 8088 can function at maximum speed but still use slower memory than the other microprocessors. In many cases (especially EPROMs), slower-memory-speed selected parts have much lower prices than faster selections.

Essentially, the 8088 has from 1.5 to 2.5 times the performance of the fastest 8-bit competition. Of course, the performance improvement over older 8-bit processors (ie: 6800s, 8080As, etc) is even higher.

Finale

In the text box on pages 344 thru 346 you will find a full description of each MON88 command. A complete listing of the monitor program is given in listing 1.

The 8088 is not only the highest performance 8-bit processor available, but represents a "bridge" to the new architectures of the 1980s. I hope that you have found the 8088 project as challenging, educating and rewarding as I have. Welcome to the future! ■

Add Macro Expansion to Your Microcomputer

Part 2

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Last month, I discussed the definition and use of the macro instruction and detailed a set of requirements for a macro processor. Part 1 also gave an overview in the form of text and flowcharts of how this macro processor would operate. Figures 1 thru 11 provide a more detailed flowchart of these processes and roughly correspond to the overview flowcharts in figure 1 of Part 1 of this article (October 1980 BYTE, page 162). Frequent reference should be made back to these overview flowcharts when reading the detailed flowcharts of figures 1 thru 11. A glossary of terms appears on page 371.

This completes the explanation of the macro definition and expansion. In the rest of the article I will discuss the interface of the macro processor to an assembler, as well as possible enhancements.

Alternate Implementation Approaches

The last hurdle to clear is how to tie this macro facility into your assembler. Basically, there are two ways this can be done, *preprocessor* or *in-line*. The approach used depends upon your situation.

The simplest way to use your macro processor is as a preprocessor. This can be done in two ways. In the first way, the macro processor is a separate program, reading your source program and writing an output file of expanded code to cassette, paper tape, floppy disk, etc; it is this output file that is read into the assembler instead of the original source. While this is the easiest way to use the preprocessor, it is also the worst from the viewpoint of efficiency, requiring an intermediate file and a longer run time. However, if you cannot modify the assembler itself, this may be the only approach you can take.

A second, more efficient, preprocessor approach is to locate the read routine in the assembler and replace it

Listing 1: *Example of keyword parameters. A change that can be made in the macro assembler involves the use of keyword parameters. These allow the user to specify variable symbol values in any order or by default. The macro definition for MOVE is given in listing 1a; two examples of a macro call and its resulting code are given in listings 1b and 1c. In listing 1b, both &TO and &FROM are assigned the default values given in the prototype statement of the macro definition. In listing 1c, the value for &FROM is specified by default. Note the absence of the ampersand in naming variable symbols within the macro call.*

```
(1a)
             MACRO
      &JUMP  MOVE    &TO=FIELDB,&FROM=FIELDA,&LENGTH=
             LXI     B,&TO
             LXI     D,&FROM
             MVI     H,&LENGTH
      &JUMP  LDAX    D
             STAX    B
             INX     B
             INX     D
             DCR     H
             JNZ     &JUMP
             MEND

(1b)  LOOP   MOVE    LENGTH=10

             LXI     B,FIELDB
             LXI     D,FIELDA
             MVI     H,10
      LOOP   LDAX    D
             STAX    B
             INX     B
             INX     D
             DCR     H
             JNZ     LOOP

(1c)  LOOP   MOVE    LENGTH=9,TO=NEW

             LXI     B,NEW
             LXI     D,FIELDA
             MVI     H,9
      LOOP   LDAX    D
             STAX    B
             INX     B
             INX     D
             DCR     H
             JNZ     LOOP
```

with a call to the macro processor. This is the direction taken in my flowcharts since it is a compromise between a separate program and making major revisions to the assembler.

Replacing the read routine is not as easy as it sounds, however. Microprocessor assemblers typically use character assembly rather than line assembly. They read the source statement one character at a time and process each character as it is read rather than reading an entire source statement and having the whole statement available to work on. My flowcharts are designed for line assembly in that a model statement is completely expanded before it is passed to the assembler.

If your assembler uses character-assembly processing, it will call the macro processor for each character. This will require the read routine to expand the model statement on the first call and pass it one character at a time to the assembler on successive calls until it is completely transferred, at which point the read routine will expand the next model statement. You can also modify the model-expansion routines to pass the statement a character at a time directly from the expansion routines, but this is a little more difficult.

The worst drawback of either preprocessor approach is that every operation code is looked up twice, once by the macro processor to check for macro calls and once by the normal assembler. This is quite time-consuming. Perhaps the most efficient way to incorporate macro processing is to put the macro processing in-line with the assembler's operation-code-lookup and read routines. This requires

Text continued on page 366

The worst drawback of the preprocessor approach is that every operation code is looked up twice.

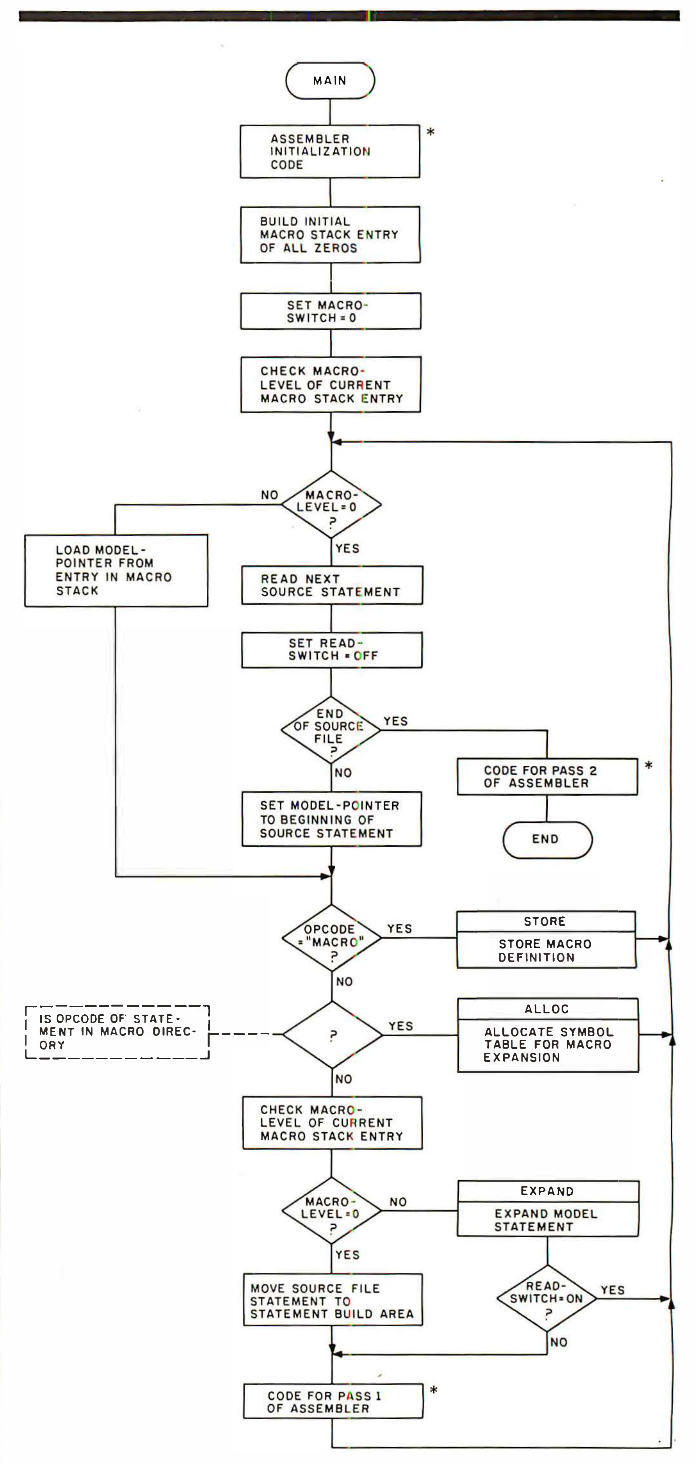


Figure 1: *Overview flowchart for macro definition and expansion. This flowchart, MAIN, takes an assembly-language file containing both macro definitions and macro calls, stores the definitions, expands macro calls, and completes the work of a regular assembler. The boxes marked with asterisks represent the code that performs the assembler functions; the remaining boxes represent the code that is added through modification of the assembler's "read source" routine to implement the macro facility. Refer to the flowcharts in figures 2 thru 11 on pages 363 thru 370.*

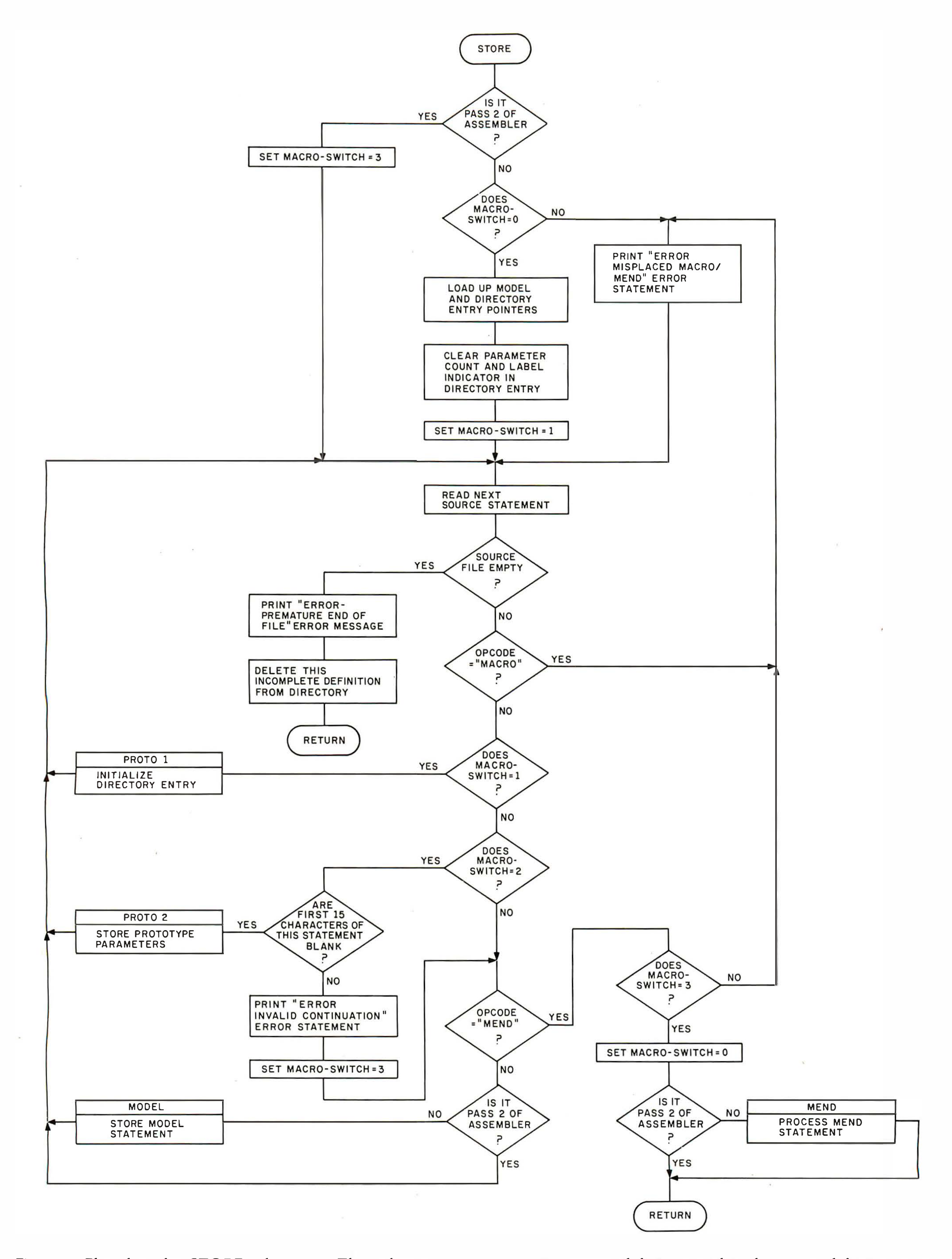


Figure 2: *Flowchart for STORE subroutine. This subroutine stores an entire macro definition within the macro-definition storage area. MACRO-SWITCH is a flag that tells the program what kind of line the routine is expecting next. MACRO-SWITCH=0 means that the computer is ready to process a new macro definition. MACRO-SWITCH=1 means that the computer has found a MACRO statement and is looking for the prototype statement. MACRO-SWITCH=2 means that the computer is ready to process the second line of the prototype statement, if there is one. MACRO-SWITCH=3 means the computer is ready to process the body of the macro definition.*

(3)

PROTO 1 → SET MACRO-SWITCH = 2 → DOES STATEMENT HAVE A LABEL? (NO → skip to STORE OPCODE) YES → VALIDATE VARIABLE SYMBOL LENGTH → ADD 1 TO PARAMETER COUNT IN DIRECTORY ENTRY → STORE LABEL IN VARIABLE SYMBOL 1 OF DIRECTORY → MOVE 1 TO LABEL INDICATOR IN DIRECTORY ENTRY → STORE OPCODE IN MACRO NAME OF DIRECTORY ENTRY → PROTO 2 / STORE PROTOTYPE PARAMETERS → RETURN

Figure 3: *Flowchart for PROTO1 subroutine. This subroutine stores the prototype label, if any, the macro name, and calls PROTO2 to store the prototype variable symbols.*

Figure 4: *Flowchart for PROTO2 subroutine. This subroutine stores the variable symbols of a macro prototype statement in the directory.*

Figure 5: *Flowchart for MEND subroutine. This subroutine does several housekeeping chores associated with ending a macro definition.*

(4)

PROTO 2 → LOCATE NEXT OPERAND ON PROTOTYPE STATEMENT → ANY MORE OPERANDS? YES → VALIDATE VARIABLE SYMBOL LENGTH → ADD 1 TO THE PARAMETER COUNT IN DIRECTORY ENTRY → STORE SYMBOL IN NEXT VARIABLE SYMBOL OF DIRECTORY → (loop back to LOCATE NEXT OPERAND)
NO → IS THIS STATEMENT CONTINUED? (YES → RETURN) NO → SET MACRO-SWITCH TO 3 → RETURN

(5)

MEND → STORE A FORM FEED CHARACTER AT POSITION GIVEN BY MODEL-POINTER → ADD 1 TO MODEL-POINTER → CALCULATE LOCATION OF NEXT DIRECTORY ENTRY → STORE VALUE OF MODEL-POINTER IN NEXT DIRECTORY ENTRY → SET MACRO-SWITCH=0 → RETURN

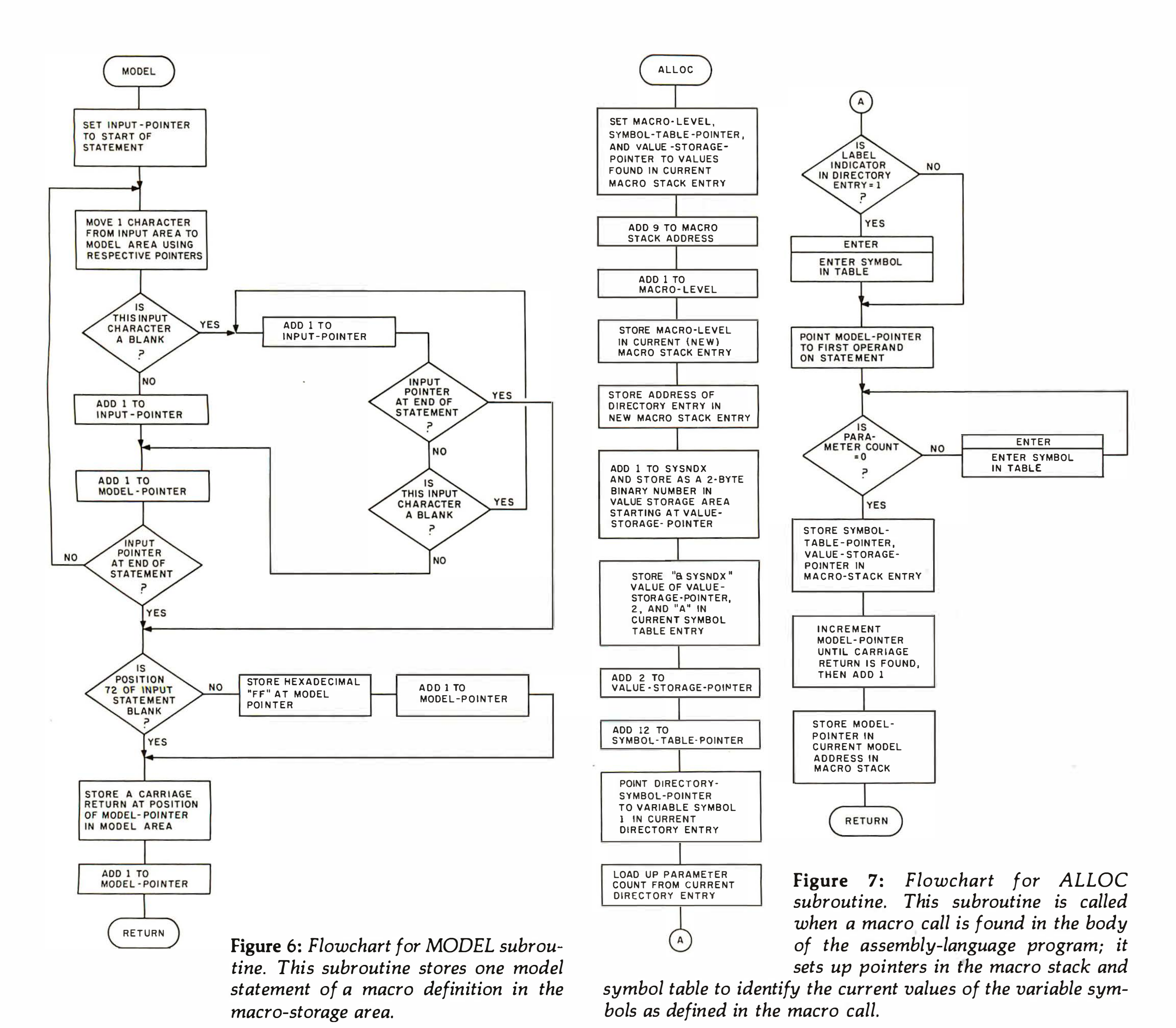


Figure 6: *Flowchart for MODEL subroutine. This subroutine stores one model statement of a macro definition in the macro-storage area.*

Figure 7: *Flowchart for ALLOC subroutine. This subroutine is called when a macro call is found in the body of the assembly-language program; it sets up pointers in the macro stack and symbol table to identify the current values of the variable symbols as defined in the macro call.*

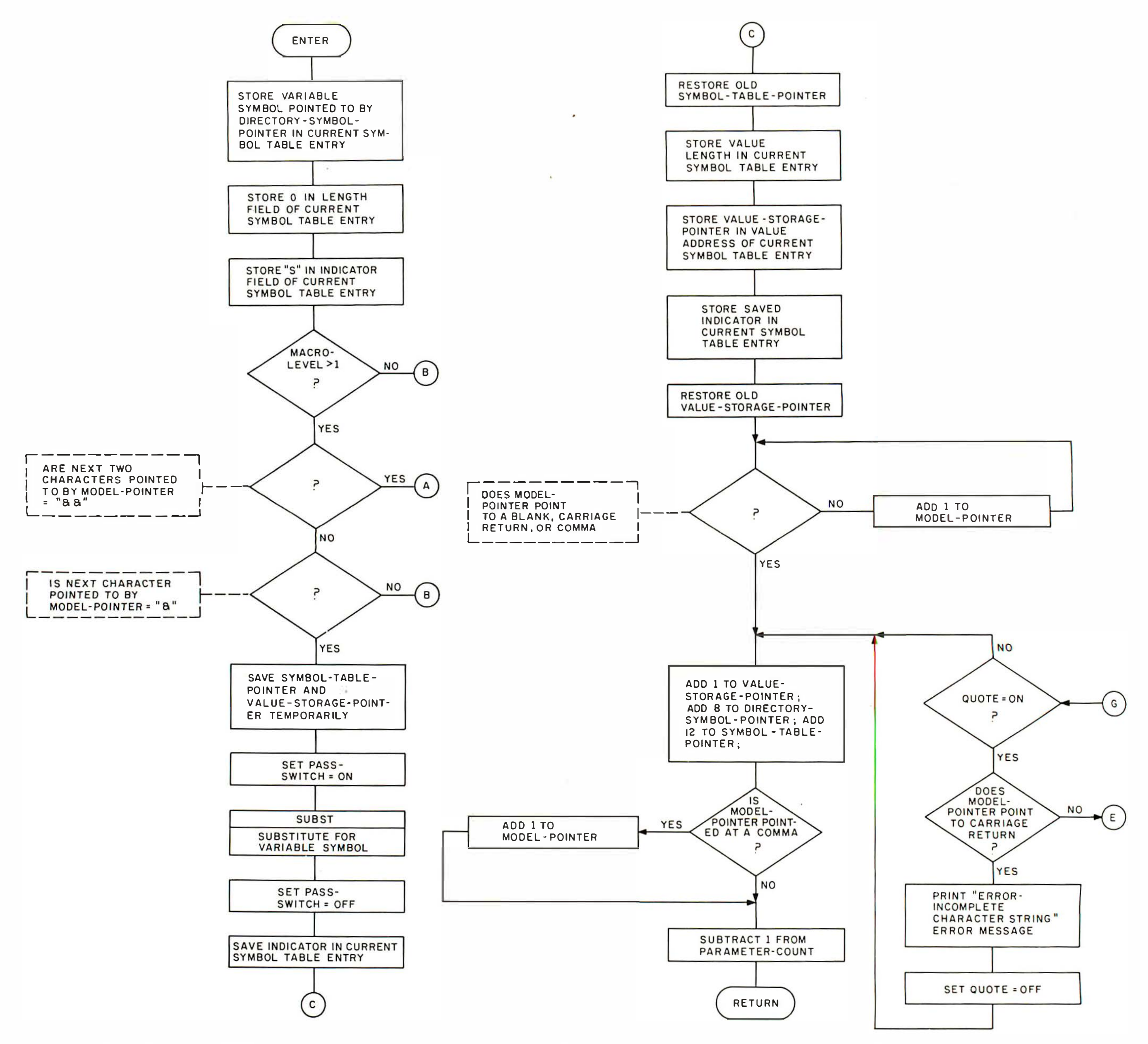


Figure 8: *Flowchart for ENTER subroutine. This subroutine, called by ALLOC, stores the current value of a variable symbol in the symbol table.*

Text continued from page 362:
source listings for your assembler and enough courage on your part to modify your assembler. The operation-code-lookup routine must be modified to first check for the identifier MACRO, at which point it stores the definition. If the operation code is not MACRO and is not found in the assembler's operation-code table, the assembler must then look it up in the macro directory and expand it if found.

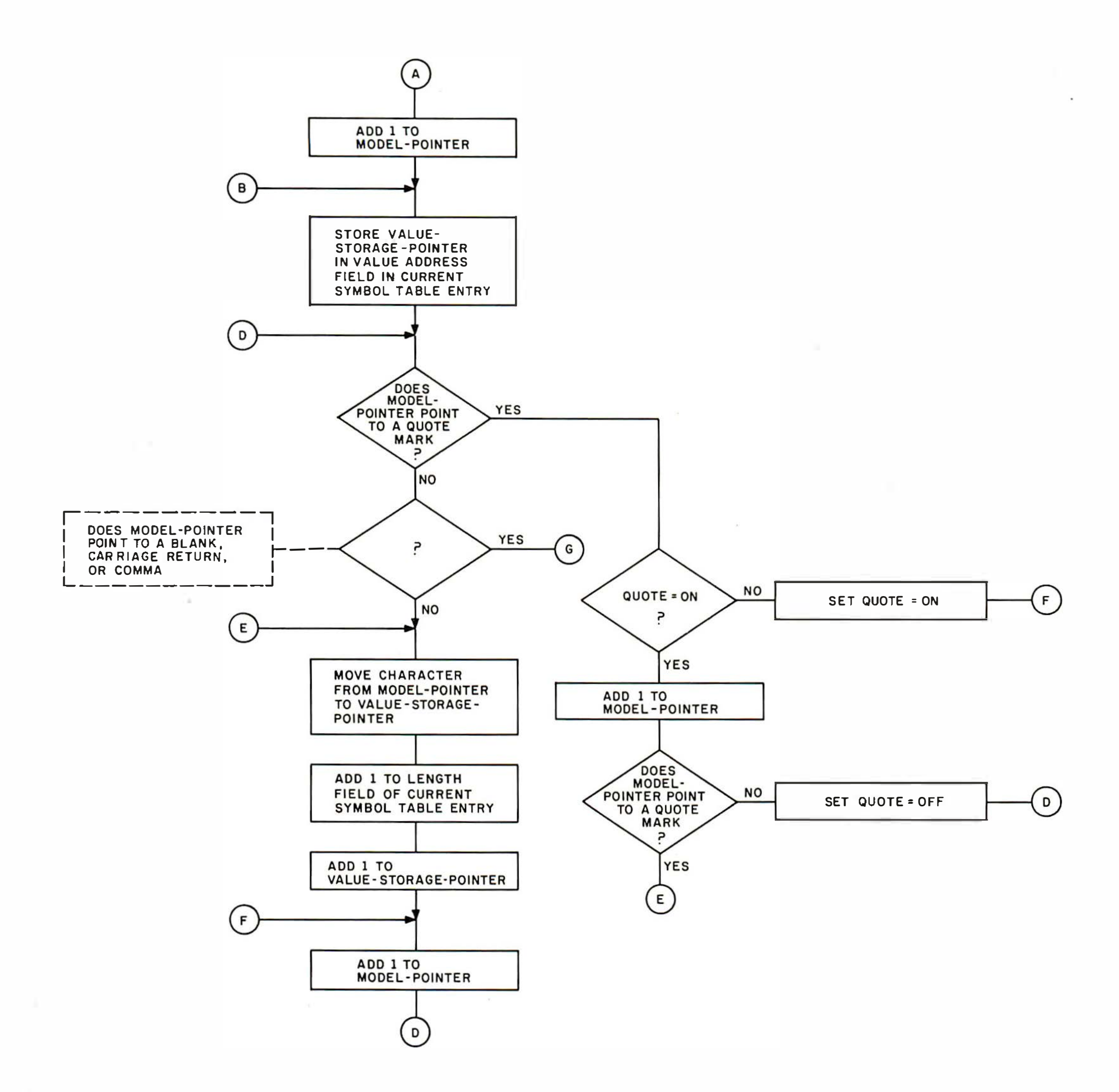
In using this in-line approach, you also have to modify the read routines to make use of the macro-level counter, as is done at the beginning of the flowchart in figure 5. This approach, more ambitious than the others, is the best, and it should be taken if you have the assembler source and can take the time. It will result in an efficient, well-integrated assembler, rather than a patchwork creation. However, if this route cannot be taken, the power of macro facilities is probably worth the inefficiency of the preprocessor technique.

Extensions

If you are really ambitious, there are several other facilities that you can implement. Many of these facilities require modifications to the assembler as well as to the macro processor; but if you are still reading at this point, maybe you feel up to the task.

A large improvement can still be made in print facilities. As detailed so far, the macro call itself never gets to the assembler for printing so that you do not know from looking at the intermediate source listing which statements are generated by the macro assembler and which are in the original source. Ideally, the macro call should print and all generated statements should be identified as such. One solution is to print the macro-level indicator, since this shows the level of nesting when nested macro calls are used. You can also add an assembler directive that tells the assembler whether or not to print the generated statements.

Another facility that you can implement is conditional



assembly, which was mentioned in Part 1 of this article. This would go along with the ability to define local variable symbols within the body of the macro definition; these local variable symbols would be used for loop control and arithmetic within the macro definition.

Another possible modification is the addition of global symbols and a global symbol table. This would allow you to pass variable symbols from one macro expansion to another. When a global symbol is encountered, you look it up in the global symbol table to get its value. If it is not found there, it is added to the global symbol table. This global table does not have its entries deleted at the end of the macro generation, so the information put there is still present whenever the next macro call is processed.

The method for handling variable symbols and their values detailed in this article is known as *positional parameters.* This means that the first variable symbol on the prototype assumes the first value on the macro call, the second variable symbol assumes the second operand value, and so on. A more flexible method is *keyword parameters*. With keyword parameters, the macro prototype might look like this:

```
&LABEL  MOVE  &FROM=FIELDA,
    &TO=FIELDB,&LENGTH=
```

The macro call would then be coded:

```
LOOP2  MOVE LENGTH=14,FROM=FIELDC
```

Keyword operands are distinguished by an equals sign and have several interesting properties. As shown in listing 1a, the &FROM= and &TO= variable symbols in the prototype specify a default value—FIELDA and FIELDB, respectively. If the FROM and TO operands are omitted on the macro call, the defaults are used as in listing 1b; otherwise, the value from the macro call is used, as in listing 1c. The &LENGTH= parameter on the prototype has no default, so it must be specified on the macro call. Also, since you specify the keywords on the macro call, they do not have to be in the same order as specified on the prototype. Otherwise, the keywords are used in the macro-definition statements just like the positional parameters I have been discussing.

Keyword processing requires a more complicated loading of the symbol table when the macro call is encountered; it also requires modifications to the routine that stores the macro definition, since the defaults will have to be stored in the value-storage area and the directory entries will have to be modified to point to the default values. It is a lot of work, but it is much more flexible.

These are just some of the enhancements you can implement. If you have access to the IBM Assembler Language manual (referenced at the end of this article), you will find that it gives much more detailed explanations of these facilities, plus others that I have not mentioned.

To those of you who are still interested, study of the text and flowcharts of this article is all you need do before you can write your own macro assembler. Once you understand the processes involved ("walking through" the flowcharts with pencil and paper will help), there is no reason why you cannot give it a try. After all, there's no magic to system software—it's just another program. ■

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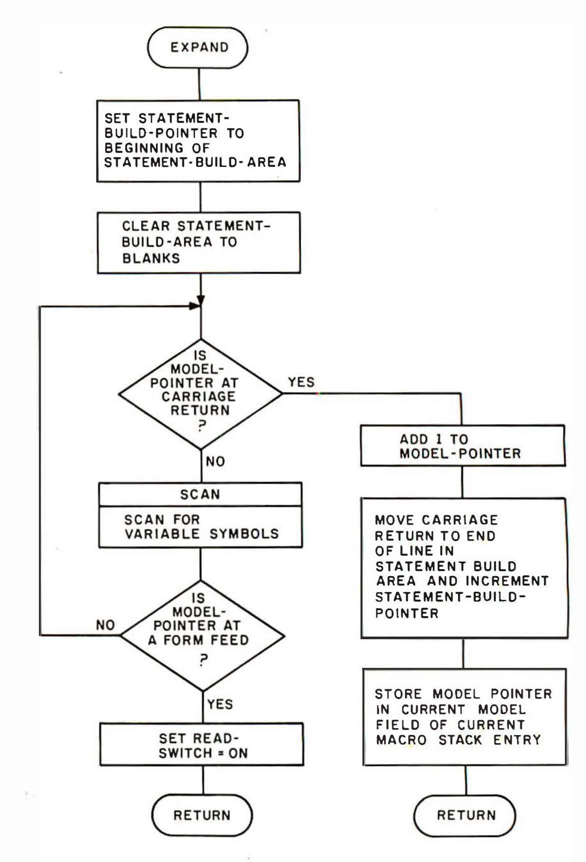


Figure 9: *Flowchart for EXPAND subroutine. This subroutine expands a model statement using the current values of the variable symbols as found on top of the symbol table.*

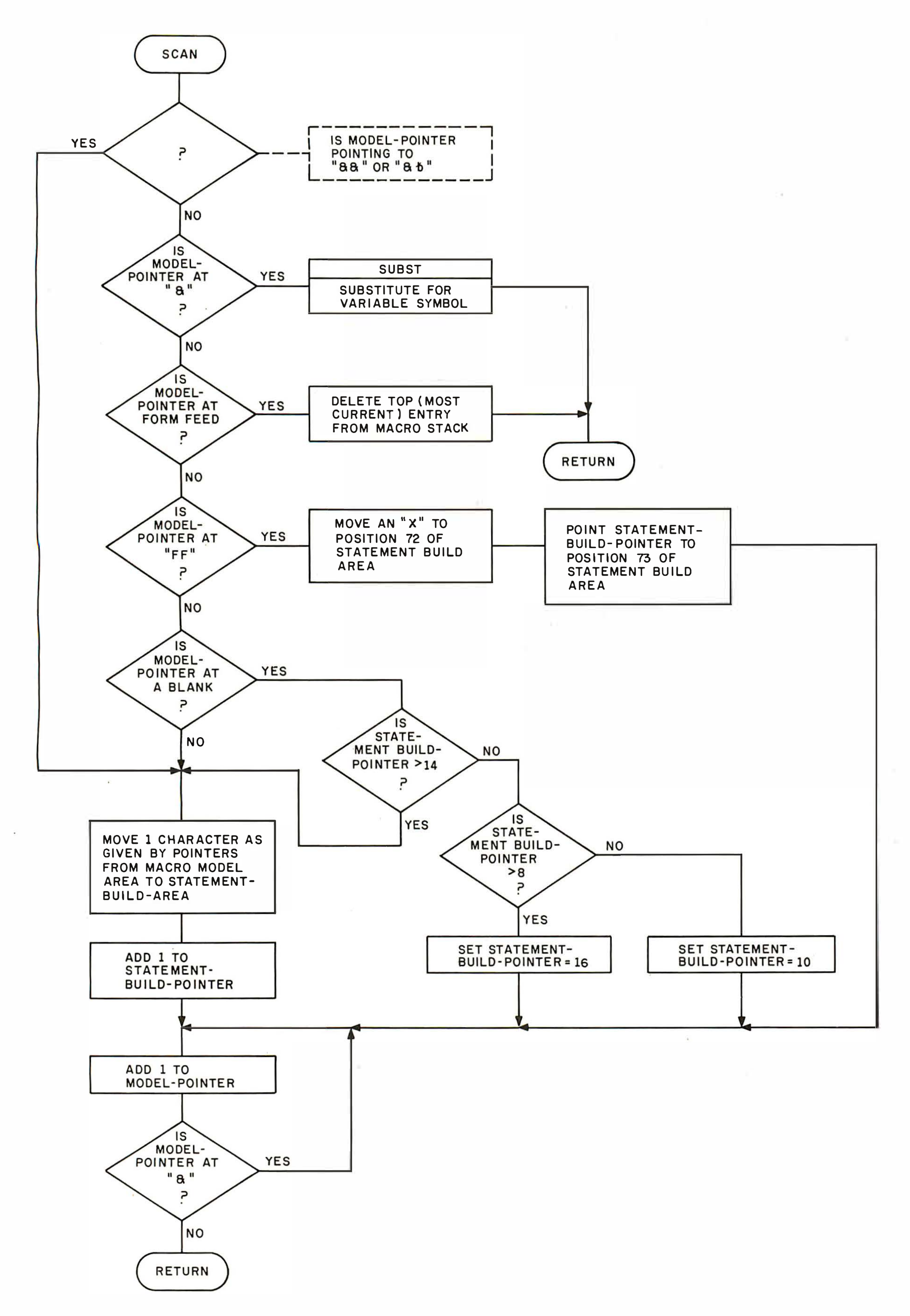


Figure 10: *Flowchart for SCAN subroutine. This subroutine scans for variable symbols in the model statement and replaces them with their most recent values; it also restores blanks that were compressed out of the model statement.*

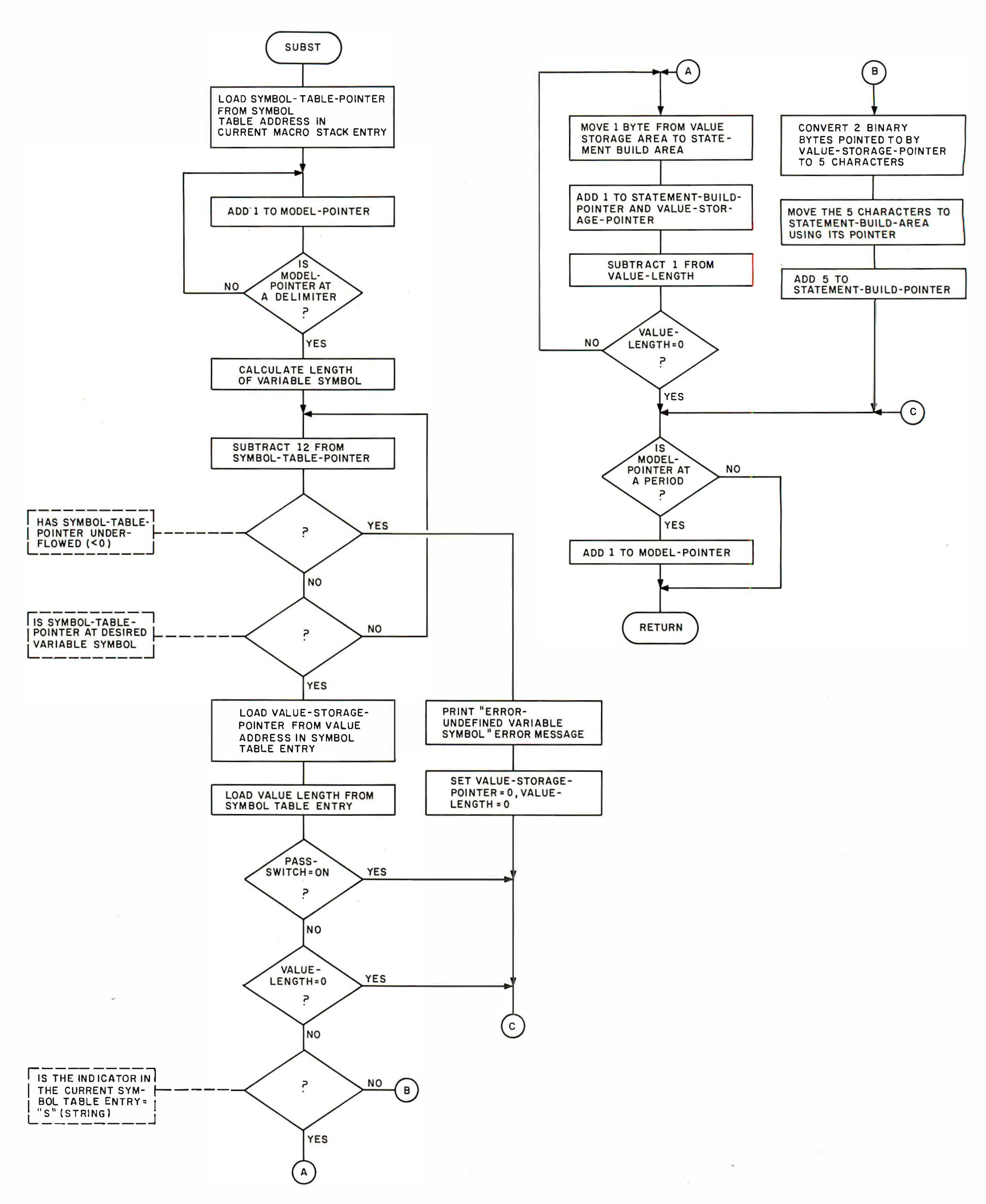


Figure 11: *Flowchart for SUBST subroutine. This subroutine, called by SCAN, substitutes the appropriate value for its corresponding variable symbol in a model statement.*

GLOSSARY

Conditional Assembly: *a feature of macro assemblers that instructs the assembler to generate or leave out certain lines of assembly-language code based on a given condition evaluated at the time of expansion.*

Descriptor: *useful when working with strings of characters. It is a fixed-length entry containing the length of the string and a pointer to where the string starts in the storage area. (Symbol-table entries can be considered descriptors.) Descriptors are used frequently in assemblers and in high-level language compilers.*

Directory: *it contains an entry for every macro defined, pointing to the start of the model statements and specifying the variable names (from the macro prototype) that must be entered into the symbol table before the macro is evaluated.*

Global Variable: *a variable whose value is in effect for the entire assembly and for every macro generation. Use of a given global variable name, even within different macros, refers to the same value (unlike local variable symbols, the values of which are lost at the end of the macro expansion). In this article, &SYSNDX is a global variable.*

Inner Macro: *a macro call specified within the model statements of another macro. When a macro referred to as the outer macro is generating statements and encounters an inner macro, it must stop, generate the statements from the inner macro call, add them to the statements belonging to the outer macro, then continue generating its own statements.*

Keyword Operand: *a variable symbol followed by an equals sign; it appears only on the macro prototype and the macro call. Unlike positional parameters, keyword operands can be coded in any order. They also allow the ability to specify default values in the macro prototype.*

Local Variable: *a variable, the value of which is in effect only for the macro in which it is defined. All variable symbols defined in macro prototype statements are local variables. The same local variable symbol name used in another macro is treated as a separate variable, even though the names are the same.*

Macro: *a user-defined assembly-language operation code that generates one or more assembler instructions.*

Macro Call: *a pseudoinstruction within an assembly-language program that refers to a macro definition of the same name. The eventual result is the replacement of the macro call statement with the expanded model statements of the macro definition.*

Macro Definition: *a sequence of statements that tell the macro processor what to generate when replacing the macro-call instruction. It is made up of a MACRO statement that signals the beginning of the macro, a prototype statement that defines the macro name and its operands, a series of model statements that replace the macro call, and a MEND statement that signals the end of the macro definition.*

Macro Stack: *a stack of certain information about currently incompleted macro calls; it is necessitated by the ability to call a macro within a macro. Each macro-stack entry points to the directory entry, the end of the symbol table, and the value-storage area for the macro.*

Model-Storage Area: *an area of computer memory set aside for storing the model statements of all macro definitions. The directory entry for each macro points to the start of that macro's model statements in the model-storage area.*

Pass 1: *the assembler's first reading of source statements. During pass 1, the assembler builds its symbol table, which includes every label in the program, and checks for duplicate symbols.*

Pass 2: *the assembler's second reading of the source statements. At this point, all symbols are known to the assembler as a result of pass 1, and the equivalent machine code can be generated from the source code.*

Positional Operands: *when the variable symbols in a macro prototype are defined as positional operands, they are assigned values from the list of operands in the macro-call statement in the order that they are defined in the prototype. The first variable symbol on the prototype gets the first operand value, and so on.*

Preprocessor: *a routine or program that processes and usually modifies the input before the main program gets it. Macro facilities are often written as preprocessors that replace macro calls with their expanded assembly-language statements before passing the source file to the assembler.*

Prototype: *the second statement in the macro definition. It defines the label entry, the operation code (macro name), and the allowable operands (in the form of variable symbols) for the macro call.*

Recursion: *a technique in which a called subroutine calls itself. A recursive function must be designed so that it eventually returns a value rather than calling itself again; otherwise, it calls itself in a loop that never finishes.*

Stack: *a last-in, first-out list that allows the user to remove only the value most recently placed onto the stack. Stacks are similar to the devices used to dispense plates in a cafeteria. Plates (values) are put on the top of the stack, pushing down all the others, and are removed from the top, causing the others to pop up. A stack in programming works the same way, giving rise to the terms PUSH and POP, which are commonly used when talking about computer stacks.*

Symbol Table: *a stack containing an entry for each variable in the macro prototype. The symbol-table entry specifies the variable name, the length of its current value, and the address where the value is stored in the value-storage area.*

Text Compression: *the process of removing all unnecessary blanks from a source statement in order to reduce the amount of space needed to store the text.*

Value-Storage Area: *an area of memory set aside for storing the values associated with a program's variables. The symbol-table entry for each variable points to the start of that variable's value and specifies the value length.*

Variable: *a variable (or variable symbol) is a character string that can have many different values assigned to it by either the programmer or the assembler. Variables can be either global or local; most references to variable symbols in this article actually refer to local variable symbols.*

What's New?

PERIPHERALS





Floppy-Disk Drive for the HP-85

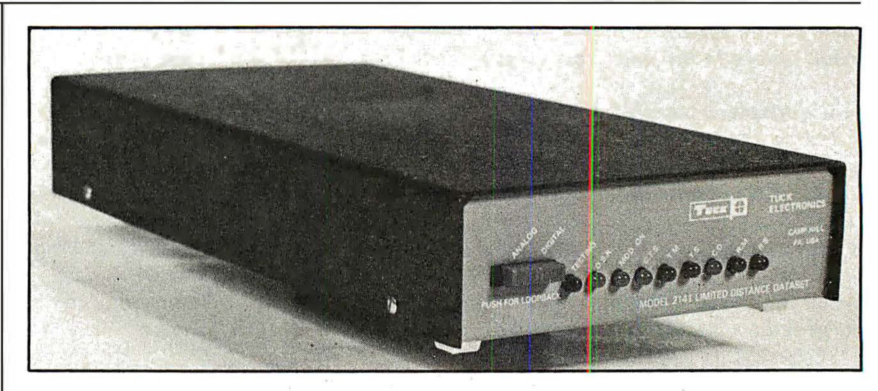
The HP 82900 Series floppy-disk drives read double-sided, double-density, 5-inch floppy disks, and can be configured to provide from 279 K bytes to 1.08 megabytes of storage. The interface between the HP-85 and the disk drives is the HP-85 Mass Storage ROM (read-only memory). The ROM makes available thirty additional BASIC commands including a Translate command, which upgrades written tape-based programs for use on the drives; the ability to store and retrieve the graphics display on the video screen; automatic default to the drive; and volume labeling, allowing users to refer to disks by name and write programs independent of drive addresses. Prices for the floppy-disk drives start at $1500 for a single-master drive and go to $2500 for a dual-master drive. Contact the Inquiries Manager, Hewlett-Packard Co, 1507 Page Mill Rd, Palo Alto CA 94304.

Circle 662 on inquiry card.

Seven Spinwriter Thimble Fonts from NEC

NEC Information Systems Inc, 5 Militia Dr, Lexington MA 01273, (617) 862-3120, has introduced Pica 10 Multilingual, Elite 12 Multilingual, British Elite 12, Greek/Times Roman, Scientific Times Roman, Super Courier/Publishers, and Light Italic/Manifold type fonts. These fonts meet the special printing requirements of many industries. The multilingual fonts offer the capability of printing over thirty languages. The fonts are offered on the NEC Spinwriter series of 55 character per second impact printers which feature the "thimble" print element.

Circle 663 on inquiry card.



Line Driver Meets Bell Metallic-Line Specifications

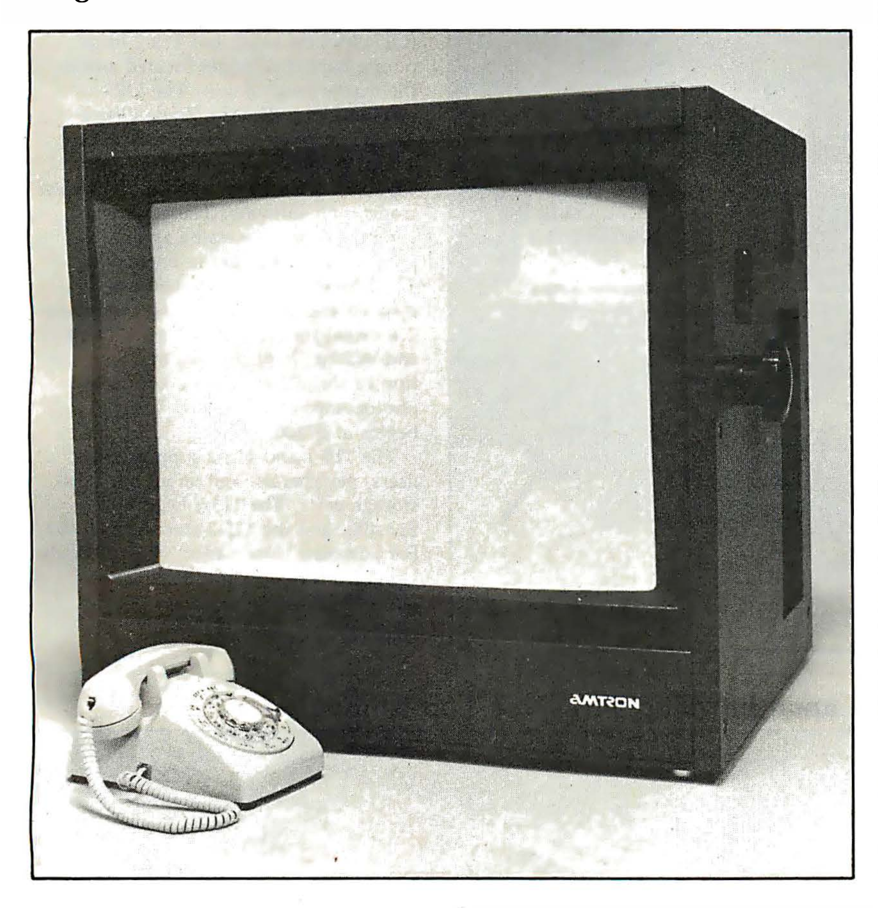
Tuck Electronics has announced a line-driver series for use on metallic pairs from 0 to 9.6 kbs for 4-wire full-duplex service. The driver complies with Bell 43401 amplitude and line balance specifications, and features a floating receiver amplifier. The unit features analog and digital loop-back test facilities, and a blinking light which indicates when the driver is in the test mode. The driver supports an RS-232 interface. The unit is available in stand-alone and multiple units. Single unit price for stand-alone units is $175, and multiple-unit cards are $162. For more information, contact Tuck Electronics Inc, 3645 Industrial Park Rd, Camp Hill PA 17011, (717) 761-4354.

Circle 664 on inquiry card.

Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgement the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first in first out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

Large-Screen Color Monitor



The AM-26, a 26-inch color monitor, with over 340 square inches of screen surface, combines Sony's Trinitron color system with switchable A/B inputs, switchable underscan, internal and external sync, and separate RGB (red, green, and blue) gun switches. Talley light, separate horizontal and vertical scan delay are optional, and a separate tuner/audio amplifier and speaker section may be added. The Amtron AM-26 is priced at $2395 from Amtron, Aptos CA 95003, (408) 688-4445.

Circle 665 on inquiry card.

Digital Plotters from Houston Instrument

The DMP family of plotters comprises two standard and four intelligent models. All these models are available with plotting sizes of 21.5 by 28 cm (8.5 by 11 inches) and 28 by 44 cm (11 by 17 inches). The DMP-2 is a 21.5 by 28 cm plotter with an RS-232C and parallel interface. It has a pen speed of 2.4 inches per second and can plot at 100 or 200 increments per inch. The DMP-5 has a surface area of 28 by 44 cm and the RS-232C and parallel interface. The unit is plug-compatible with the DMP-2 and can utilize software developed for the DMP-2. The DMP-3 features a built-in microprocessor and pen speeds of 3 inches per second. Use of Houston Instrument's Digital Micro/Plotter Language alleviates the software burden on the host computer. Self-test and pen positioning are accomplished via a computer or terminal keyboard. The DMP-3 comes with an RS-232C or Centronics-compatible interface. The DMP-6 is a 21.5 by 28 cm version of the DMP-3 and features a pen speed of 2.4 inches per second. The DMP-4 and the DMP-7 utilize electronic controls to facilitate positioning of the X and Y axes. Self-diagnostics are activated through front panel controls. Prices for the DMP Series plotters start at $1085. For complete information, contact Houston Instrument, 1 Houston Sq, Austin TX 78753, (512) 837-2820.

Circle 666 on inquiry card.

Paper-Tape Reader

A paper-tape reader/transmitter, the Model 612, is available from Addmaster Corporation, 416 Junipero Serra Dr, San Gabriel CA 91776, (213) 285-1121. The 612 features the ability to read five- to eight-level tape and to transmit 7 to 11 frames per character at 50 to 9600 bps (bits per second). Other features include starting and stopping on character at all speeds; choice of manual or automatic control; 90 to 260 V, 50 to 60 Hz power sources; and even, odd, or no parity; with a choice of desk-top or rack mounting. The price is $656 to $779.

Circle 667 on inquiry card.

Chatterbox from Micromint



The Chatterbox is a packaging combination of the presently available COMM-80 I/O (input/output) interface for the TRS-80 and an acoustic modem. This box can turn even a 4 K-byte TRS-80 into a full time-sharing terminal. The Chatterbox includes a built-in programmable 50 to 19 K bps (bits per second) serial port, a Centronics-compatible parallel printer port, a 300 bps acoustic originate modem, and a spare TRS-BUS expansion connector. It comes with a power supply, connection cable, manual, and smart terminal software. When the modem is in use, the data conversation is automatically routed to the serial output port for printing. The Chatterbox allows a TRS-80 to communicate with time-sharing systems such as Micronet and the Source. In addition, Chatterbox can be used simply to provide an address selectable serial and parallel port. It is completely hardware- and software-compatible with existing TRS-80 products, and it connects either to the keyboard connector or screen printer port on the Expansion Interface. It does not require the Expansion Interface for operation. The Chatterbox is available for $259 from The Micromint Inc, 917 Midway, Woodmere NY 11598, (516) 374-6793.

Circle 668 on inquiry card.

What's New?

SYSTEMS



Systems from Wang

The Office Information Systems (OIS) Models 115-1 and 115-2 incorporate hard-disk drives located within the master control unit. The OIS systems can utilize the Wang Office-BASIC language, telecommunications and high-speed image printing capabilities, and Wang MAILWAY electronic mail software. These systems combine word-processing and data-processing capabilities in one device. The Model 105 supports two workstations and one printer, and contains a 2.5-megabyte hard disk. The addition of text editing, hyphenation, and justification to the 105 provides a complete photocomposition system. The 105 begins at $9300.

The 115-1 and 115-2 support more users, peripherals, and larger hard-disk storage units. The 115-1 begins at $13,400, and the 115-2 starts at $15,400. For complete information, contact Wang Laboratories Inc, 1 Industrial Ave, Lowell MA 01851, (617) 459-5000.

Circle 669 on inquiry card.

Casio Markets Its First Computer

The FX-9000P computer, priced under $900, has been introduced by Casio Inc, 15 Gardner Rd, Fairfield NJ 07006, (201) 575-7400. It features instantaneous operation of the user system when the power is switched on. A graphic-display system makes it possible to display graphs, diagrams, and tables. The FX-9000P has all functions necessary to perform scientific and technical calculations and business analyses. The machine accepts memory packages to expand memory capacity.

Circle 670 on inquiry card.

British S-100-Based Microcomputer

The Tuscan S-100 is based on the IEEE (Institue of Electrical and Electronics Engineers) standard S-100 bus. This single-board computer uses a Z80 microprocessor, can store 64 K bytes of programmable memory, is CP/M compatible, and includes a printer interface. Expansion capabilities include high-resolution graphics and speech synthesis cards. Transam offers application software packages that include BASIC and Pascal. Tuscan S-100 prices start at £195 for kits. For details, write Transam, 12 Chapel St, London NW1 5DH, England.

Circle 671 on inquiry card.

Canon Introduces Its Desk-Top Computer



The TX Series microcomputers from Canon feature a 6809 microprocessor, extended BASIC and assembler language, a twenty-column alphanumeric video display, and a built-in twenty-six-column triple-copy impact printer. The models have 15 K bytes of user memory which can be expanded to 31 K bytes. Each model has an RS-232 interface port and a modem port. The TX-25 is a programmable machine with a full typewriter keyboard and a built-in Canon floppy-disk drive. The TX-10 and TX-15 are nonprogrammable. The TX-15 incorporates a typewriter keyboard, while the TX-10 has a ten-key pad with twenty-six labeled keys. The price for the series is $1295 from Canon Systems Division, 10 Nevada Dr, Lake Success, Long Island NY 11042, (516) 488-6700.

Circle 672 on inquiry card.

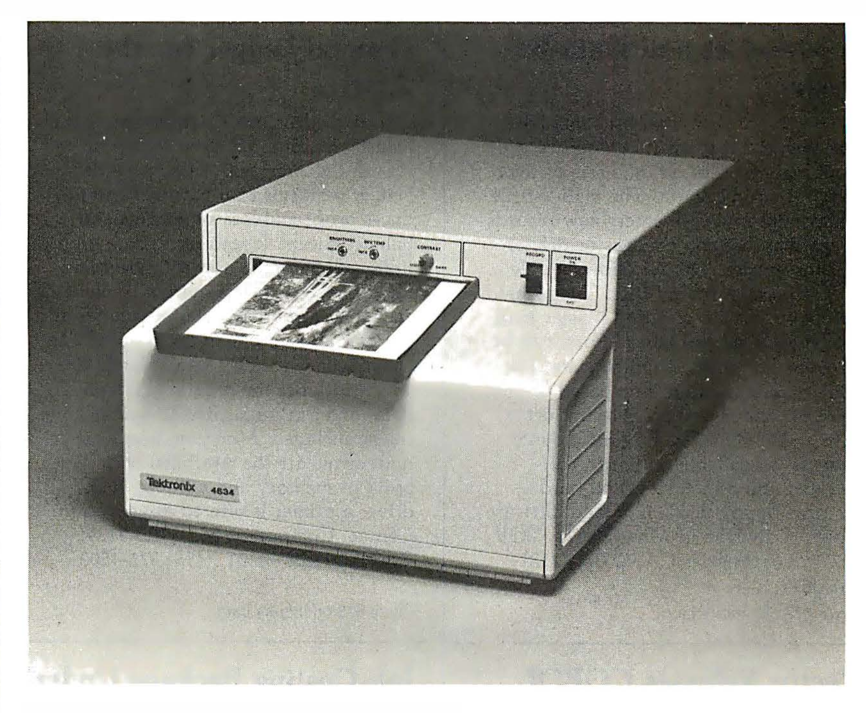
What's New?

GRAPHICS

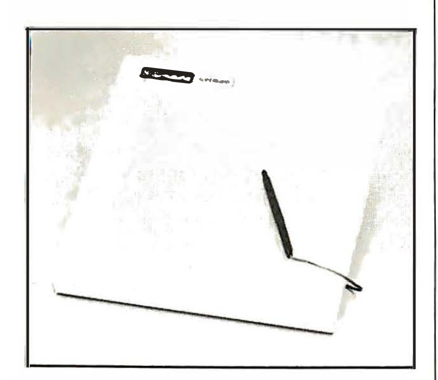
Colormaster Video and Graphics Board

The Colormaster allows users to program virtually any display format (eg: 64 by 32, 128 by 16, and 80 by 25). The board is designed for S-100 bus systems. Characters may be reversed, dimmed, flashing, underlined, and any of eight colors. Bit-mapped graphics or an optional PROM (programmable read-only memory) graphics set may also be displayed. Another option allows extension of the character set to include 128 user-defined characters. The Colormaster kit is $399; assembled and tested, it is $499; and the bare board is $79. For more information, contact MicroDaSys, POB 36051, Los Angeles CA 90036, (213) 731-0876.

Circle 673 on inquiry card.



Summagraphics Unveils Supergrid Digitizer

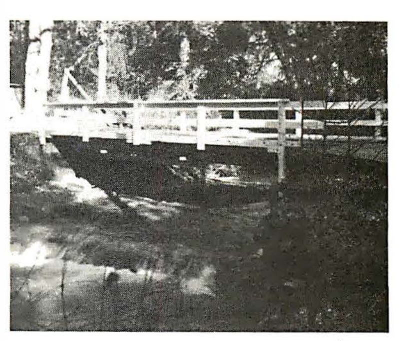


The microprocessor-based Supergrid utilizes a new technology—the Direct Magnetostrictive principle. This unit features high accuracy (±.005 inch or 0.125 mm) and high-resolution (.001 inch or 0.025 mm) and eliminates the need for a biasing magnet. Supergrid is translucent with a flat surface; moreover, it supports a stylus and a cursor, and it permits simultaneous use of two digitizer tablets with the same driving electronics. The Supergrid comes in 11 by 11 and 20 by 20 inch forms, with larger versions to follow. RS-232C, IEEE, 8-bit parallel, and 16-bit parallel interfaces are supported. The technology behind the device is based on a principle that replaces a matrix of magnetostrictive wires with a matrix of plain copper wires and only one magnetostrictive wire per axis. For more information, contact Summagraphics Corporation, 35 Brentwood Ave, Box 781, Fairfield CT 06430, (203) 384-1344.

Circle 674 on inquiry card.

Hard-Copy Unit for Video Images

The Tektronix 4634 Imaging Hard Copy Unit produces high-quality continuous tone copies from raster-scan video sources in seconds. Designed to provide photographic quality images, the device is aimed at digital image processing, pattern recognition, remote sensing, video-disk, and high-resolution display environments. The 4634 records on dry silver paper using a fiber-optic video display. The process requires no toners or developers. The copies have a twelve-tone gray-scale range. The approximate cost per copy is $0.20. It prints 6 by 8 inch images on 8½ by 11 inch paper. It is usually requires a single cable connection and can be interfaced to most raster-scan video sources, whether analog or digital. An automatic gain-control circuit tracks the input



signal. Paper is available in 8½ inch by 500 foot rolls. Paper length can be adjusted from 7 to 11 inches. For more information, contact Marketing Communications Department, M S 63-635, Tektronix Inc, POB 500, Beaverton OR 97077, (503) 682-3411.

Circle 675 on inquiry card.

Digitizer for the Apple II

The DS-65 Digisector is a random access video digitizer for the Apple II. It converts a television-camera's output into digital information that the Apple can process. The Digisector features high-resolution reproduction, sixty-four levels of gray scale, and accepts interlaced or industrial video input. The unit has on-board software featuring full screen scans directly to the Apple screen, random access digitizing by BASIC programs, line-scan digitizing for reading charts or tracking objects, and utility functions for clearing and copying the screen. BASIC programs include a burglar alarm and a graph reader. Complete source listings are included in the package. The DS-65 is used for digitizing pictures; security systems; moving-target indicators; computer portraits; reading paper tape, strip charts, bar codes, and more. The price is $349 from The Micro Works, POB 1110, Del Mar CA 92014, (714) 942-2400.

Circle 676 on inquiry card.

What's New?

SOFTWARE

A Mail-List and Data-Base System

SelectraSort is a mail-list, data-base management system. It can pull records from mail-list files on the basis of over sixty selection criteria. The mail-list-file maintenance module enters new records to the mail list and changes or deletes existing entries. The selection module pulls records form the files. The print module prints selected and master mail lists as well as mail labels. Sorts can be done by ZIP code, country, state, last activity date, amount purchased or sold last year and this year. SelectraSort is $195, which includes CBASIC source code. It is available on 8-inch soft-sectored and 5-inch soft- and hard-sectored floppy disks. Contact Software Hows, a division of MicroDaSys, POB 36275, Los Angeles CA 90036, (213) 731-0877.

Circle 677 on inquiry card.

General Ledger for the Atari

MicroLedger, the Compumax general ledger program, has been converted to run on the Atari 800. The Atari MicroLedger performs trial balances and produces profit-and-loss statements and balance sheets. It features updating options, allowing the user to review and update records in the journal or chart of accounts; a running balance column in the journal listing; and error traps. The MicroLedger package retails for $140, which includes the program, sample data, and a manual. BASIC source code is also included. Minimum hardware requirements are the Atari 800 with 24 K bytes of memory and a floppy-disk drive; a printer is offered as an option. Contact Compumax Inc, POB 1139, Palo Alto CA 94301, (415) 325-4503.

Circle 678 on Inquiry card.

Data Manager for the Apple

Information Master is a data manager for use with the Apple and includes the ability to do calculations, totals, subtotals, and more. The program lets the user define, enter, edit, sort, and retrieve data. Printed report formats using the report-generation features can be defined. Other features include screen formatting, error trapping, and the ability to add, multiply, divide, and do exponentiations. A program is included that transfers files from the Management System for use with the Information Master. For further details on the Information Master program, contact High Technology Inc, POB 14665, 8001 N Classen Blvd, Oklahoma City OK 73113, (405) 840-9900.

Circle 679 on inquiry card.

Vector Releases COBOL with Program Generator

Vector Graphic Inc has released a version of its ANSI-standard CIS COBOL, featuring program generation capability. Version 4.2 of CIS COBOL implements the eight modules necessary to meet the ANSI Level 1 standard at the low-intermediate level. The FORMS-2 utility generates data-entry screens and can create error-free data input programs without the programmer writing a line of code. It is available from Vector Graphic Inc, 31364 Via Colinas, Westlake Village CA 91361, (213) 991-2302.

Circle 680 on inquiry card.

Job-Costing Package Under CP/M

This job-costing package consists of a reporting facility, a job-costing accounts payable, and a job-costing payroll. These programs are designed to run on a Z80 or 8080 processor using the CP/M operating system. Other CP/M-like systems are also supported. The software will run on hard or floppy disks. The business applications are integrated, yet each will run singly. The price is $700 for a system from Arkansas Systems Inc, Suite 206, 8901 Kanis Rd, Little Rock AR 72205, (501) 227-8471.

Circle 681 on inquiry card.

Business Application for the HP-85

Pro-Flow can figure sales analysis, forecast performance for products, evaluate material costs, and perform cash-flow analysis for a year's operation. By mixing initial raw data values with formulas, users can make projections about future operations. Pro-Flow is designed to run on the HP-85 microcomputer. It is available at a suggested retail of $150 from Scelbi Publications, 20 Hurlbut St, Elmwood CT 06110, (203) 522-5515.

Circle 682 on inquiry card.

Disk-O-Tape

Disk-O-Tape is a utility program for the Apple II and Apple II Plus computers. It enables users to transfer the data from a floppy disk to cassette tape and back again. The program features sector-by-sector copy of a DOS 3.2 disk to tape, error detection, and a verification pass for reliability. Each tape produced by the program contains a bootstrap for easy loading on disk. The program allows user-assigned naming of tapes. Disk-O-Tape requires at least 32 K bytes of programmable memory. The program comes on a floppy disk with Testape, a program to aid in adjusting the cassette recorder for optimum performance. Disk-O-Tape costs $12 from Dann McCreary, POB 16435-B, San Diego CA 92116.

Circle 683 on inquiry card.

Lifeboat Supports the Durango F-85

Lifeboat Associates has made available its 8080 software line formatted for the Durango F-85 computer. This software, which includes languages such as BASIC, COBOL, and Pascal; word-processing systems, such as Wordstar; communication software, such as BSTAM; and complete accounting packages, is available by the implementation of CP/M. The first version of CP/M supports the F-85 with up to four floppy-disk drives. This is priced at $170. Later versions will support the 12-megabyte and 25-megabyte hard-disk systems. Contact Lifeboat Associates, 1651 Third Ave, New York NY 10028, (212) 860-0300.

Circle 684 on inquiry card.

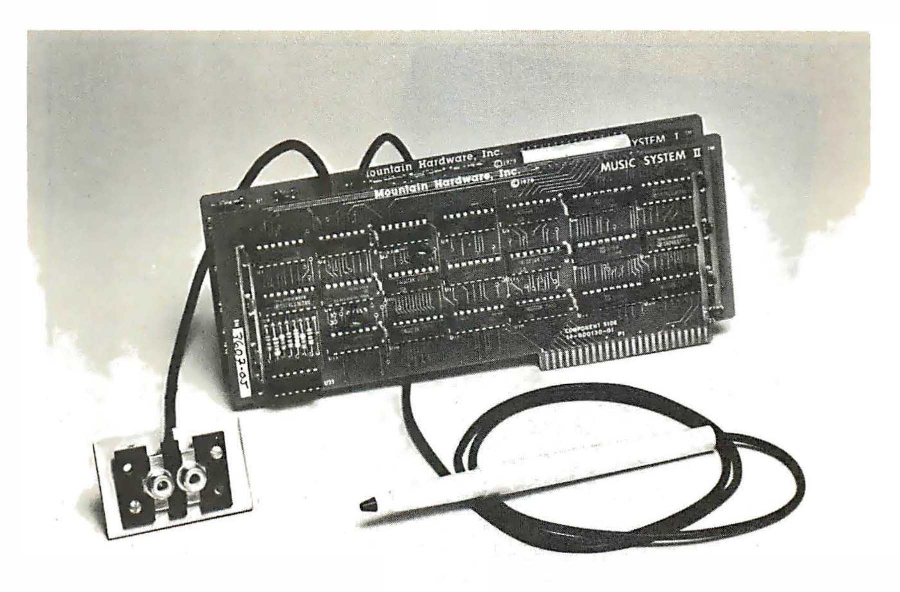
RECLAIM "Hides" Bad Sectors and Tracks from CP/M

Lifeboat Associates, 1651 Third Ave, New York NY 10028, (212) 860-0300, has announced a CP/M 2.0 utility program that tests floppy-disk and hard-disk systems for error-prone parts of the disk and allocates those parts to files that are invisible to the user. RECLAIM maps the bad spots out of the file directory so that they cannot be used again. It safely tests the disk with or without data files. At the completion of the program, it announces the number of blocks hidden from the file system. RECLAIM is available on all CP/M media formats supported by Lifeboat Associates. The cost is $80.

Circle 685 on inquiry card.

Digital Synthesizer for the Apple

Mountain Computer Inc has developed the MusicSystem for the Apple II. This sixteen-voice digital synthesizer permits the creation of the sounds of real musical instruments utilizing the principle of additive synthesis. The generation of sounds is accomplished through programmable waveforms, envelopes, and amplitudes for each musical voice. Software is included for editing and playing of compositions. The editor program permits graphical input of sheet music utilizing standard music notation. The player program permits polyphonic performance of musical compositions. Stereo output is to user's stereo amplifier and speakers or directly off card with stereo headphones. For information, write or call Mountain Computer Inc, 300 Harvey W Blvd, Santa Cruz CA 95060, (408) 429-8600.




Circle 686 on inquiry card.

New Business Software for the TRS-80

American Business Systems (ABS) has announced that its line of financial- and business-applications software packages are now available to users of Radio Shack TRS-80 computers. These seven new ABS packages offer the same full-scale features and capabilities as the company's software for larger minicomputers and microcomputers.

The packages include a complete series of financial systems, ranging from Accounts Payable and Receivable through Payroll, Order Entry and Inventory Control to a fully automated General Ledger System. The application systems currently available include Financial Modeling and Real-Estate Sales Management. Additional packages soon to be released will offer a Client Accounting System and a Correspondence Management Package, which includes a letter writter, word processor and mailing-label generator.

Information is available from American Business Systems Inc, 439 Littleton Rd, Westford MA 01886, (617) 486-3509.

Circle 687 on inquiry card.

TRS-80 CP/M 2.0 with 12 Megabytes

Lifeboat Associates, 1651 Third Ave, NewYork NY 10028, (212) 860-0300, has announced the release of CP/M version 2.0 for the TRS-80 Model II. The system features extended density format for each of up to four floppy-disk drives. Nearly 2.5 megabytes of storage is possible with floppy-disk drives alone. The Corvus 10 megabyte Winchester hard disk is suggested as a storage system, allowing CP/M to access 12 megabytes of memory. A menu-driven configuration program allows total control of the parallel printer port and both serial ports of the TRS-80.

The printer port software can be set to control a "dumb" printer that has no page control, or the software page control can be disabled for printing checks or mailing labels. The system includes functions to set data rates of from 134.5 to 9600 bps (bits per second) for the serial ports. An ADM-3A emulation program is included which allows the TRS-80 to be used as a terminal through the serial ports. The system is offered with Corvus hard-disk capability for $250 and floppy-disk capability for $170.

Circle 688 on inquiry card.

Software for the Apple II

Softpoint, Dept C, 103 Clinton Ave, Terryville NY 11776, has announced cassette programs for the Apple II including Function Plot, Speed Reading, Road Race, and more. The programs utilize the Apple's high-resolution graphics capabilities. The prices range from $5.95 to $9.95.

Circle 689 on inquiry card.

Reformat for the TRS-80

Reformat is a programming aid to be used prior to compiling with the Microsoft BASIC compiler. The BASIC compiler allows the use of long variable names which can contain BASIC reserved words, making the format of a BASIC source file and the use of spaces critical. BASIC program files that are written as multistatement compressed lines will be rejected by the compiler in almost all cases. Bluebird's has developed this machine-language program which will reformat any TRS-80 BASIC source file into a format acceptable to the compiler. Reformat is available for $24.95 from Bluebird's Company 2267 23rd St, Wyandotte MI 48192, (313) 285-4455.

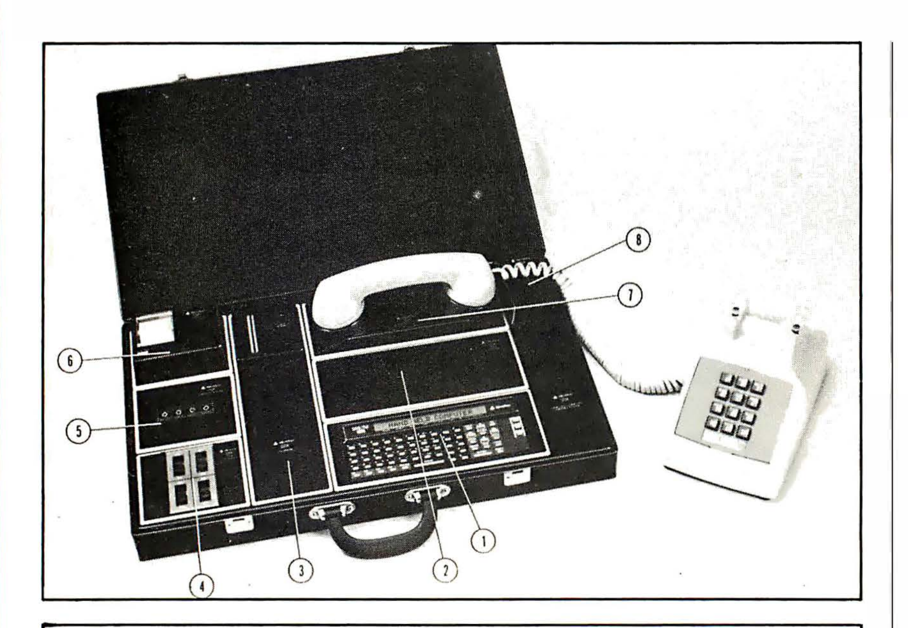
Circle 690 on inquiry card.

Data-Base Program for Z80 Systems

Condor Computer Corporation, 3989 Research Park Dr, Ann Arbor MI 48104, (313) 769-3988, has announced Target/80 DBMS, a data-base system for Z80 microcomputers. Target/80 is designed for transaction processing applications. This version uses nineteen commands, including relational operations for selecting, sorting, appending, or posting data. Target/80 is compatible with most Z80 systems with at least 48 K bytes of programmable memory running under CP/M. The price is $695.

Circle 691 on inquiry card.

MISCELLANEOUS





Computer in a Case

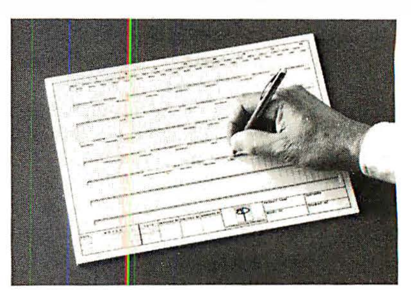
The Quasar Micro-Information System consists of a hand-held computer, video display, printer, modem, cassette deck, expandable programmable memory unit, I/O (input/output) driver—and it all fits in a briefcase. The hand-held computer fits in the palm of a hand, weighs less than a pound and controls the peripheral devices. A library of memory capsules in ROM (read-only memory) for use in the computer include fourteen languages, calorie counter, bar/wine guide, phonetic pronunciation, and games. The system is available from Quasar Company, Franklin Park IL 60131. Circle 692 on inquiry card.

Nine-Voice Synthesizer

Vista Media Products has announced the Music Machine Nine. Using LSI (large-scale integration) technology, the device can produce nine voices on the Apple II computer. The board uses three AY3-8910 integrated circuits and requires one expansion slot. It can use software now available to produce and play back nine-voice music compatible with other music boards. It will respond to commands for pitch, amplitude, duration, attack, delay, and more. Two high-impedance, low-level outputs are provided with six voices assigned to each channel. It is available through Advanced Computer Products, 1310 E Edinger, Santa Ana CA 92705, (714) 558-8813.

Circle 693 on inquiry card.

Logic Timing Recorder from A P Products



A P Products, 1359 W Jackson St, Painesville OH 44077, (800) 321-9668, in Ohio (216) 354-2101—collect, has introduced the Logic Timing Recorder, a device for charting logic timing. The unit is an ABS plastic board with 320 slides arranged in eight horizontal rows. The slides represent the two logic levels of a circuit. After the slides are manually moved into position to represent the logic state in a circuit, the board is checked for proper design, then it can be placed on a copying machine to make a permanent record for your files. The recorder may be used over and over again to chart the logic timing of all circuits. The Logic Timing Recorder, P/N 923758, has a suggested price of $44.95.

Circle 694 on inquiry card.

A/D Converter for S-100 Systems

The AIM-12 is a 16- or 32-channel 12-bit A/D (analog-to-digital) converter designed for laboratory and industrial applications. The card plugs directly into the standard IEEE S-100 bus. Features include an on-board resistor programmable instrumentation amplifier and operation of up to 25 ms with 12 bits of accuracy. The AIM-12 is I/O (input/output) mapped and can be used with either BASIC or assembly-language instructions. The module is designed for direct conversion of voltages from thermocouples, level sensors, pressure transducers, pH electrodes and other low-level signal sources. The device provides thirty-two single-ended or sixteen fully differential inputs; input impedance exceeds one billion ohms. It is fully compatible with North Star, Cromemco, and most S-100 system. Multiple boards can be employed, and BASIC and assembly-language programs are supplied. The price of the AIM-12 is from $575, depending on options, from Dual Systems Control Corporation, 1825 Eastshore Hwy, Berkeley CA 94710, (415) 549-3854. Circle 695 on inquiry card.

Speed up your PET programming with The BASIC Programmer's Toolkit,™ now only $39.95.

Don't waste valuable programming time if there's an easier way to go. Here it is: The BASIC Programmer's Toolkit, created by Palo Alto ICs, a division of Nestar. The Toolkit is a set of super programming aids designed to enhance the writing, debugging and enhancing of BASIC programs for your PET.

The BASIC Programmer's Toolkit has two kilobytes of ROM firmware on a single chip. This extra ROM store lets you avoid loading tapes or giving up valuable RAM storage. It plugs into a socket inside your PET system, or is mounted on a circuit board attached on the side of your PET, depending on which model you own.

There are basically two versions of PET. To determine which Toolkit you need, just turn on your PET. If you see ***COMMODORE BASIC*** your PET uses the TK-80P Toolkit. If you see ###COMMODORE BASIC###, your PET uses the TK-160 Toolkit. Other versions of the BASIC Programmer's Toolkit are available for PET systems that have been upgraded with additional memory.

Increase your PET's IQ™ for $39.95.

How Toolkit makes your programming easier:

FIND locates and displays the BASIC program lines that contain a specified string, variable or keyword. If you were to type *FIND A$,100–500,* your PET's screen would display all lines between line numbers 100 and 500 that contain *A$.*

RENUMBER renumbers the entire program currently in your PET. You can instantly change all line numbers and all references to those numbers. For instance, to start the line numbers with 500 instead of 100, just use *RENUMBER 500.*

HELP is used when your program stops due to an error. Type *HELP,* and the line on which the error occurs will be shown. The erroneous portion of the line will be indicated in reverse video on the screen.

These simple commands, and the other seven listed on the screen, take the drudgery out of program development work. And for a very low cost. The BASIC Programmer's Toolkit costs as little as $39.95, or at most, $59.95.

Get the BASIC Programmer's Toolkit and find out how quick and easy program development can be. See your local PET dealer or send this coupon in today.



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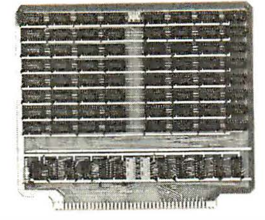
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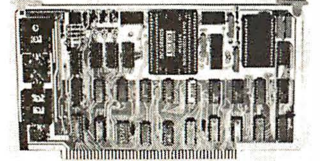
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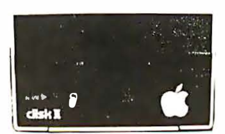
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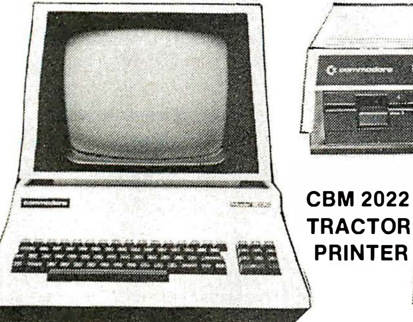
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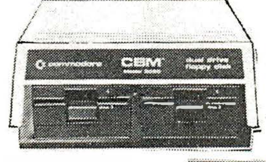
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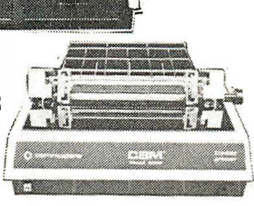
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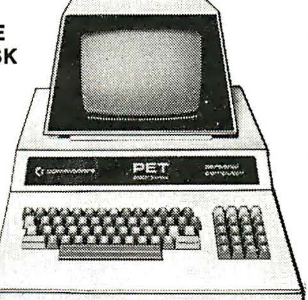
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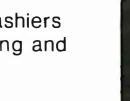
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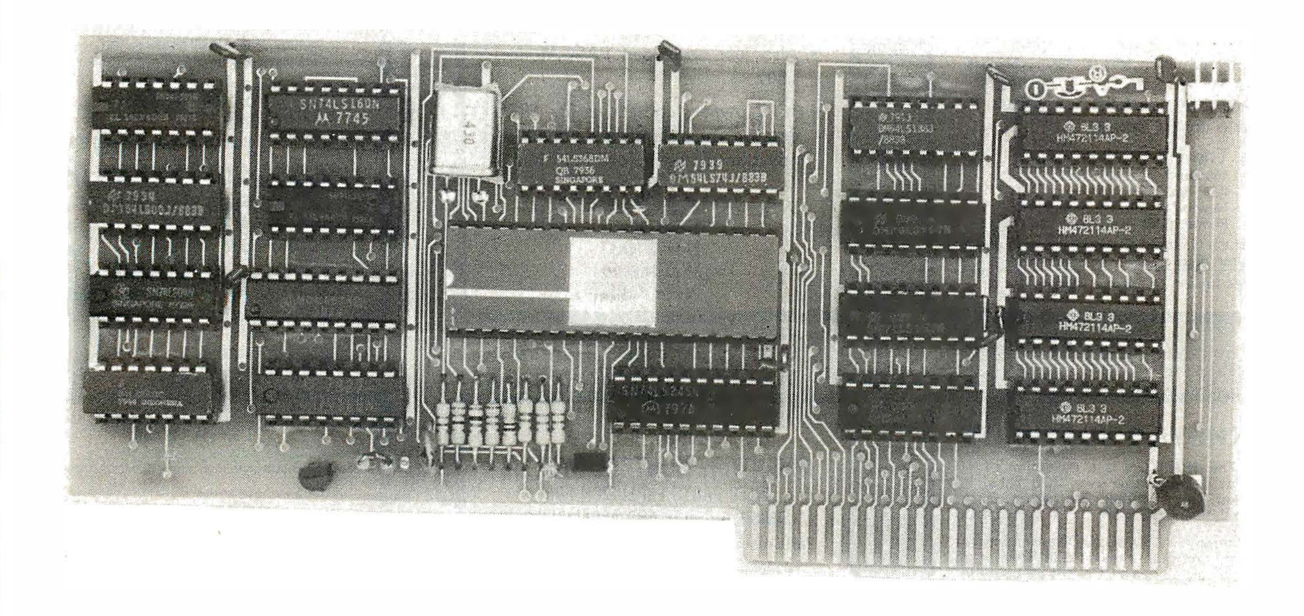


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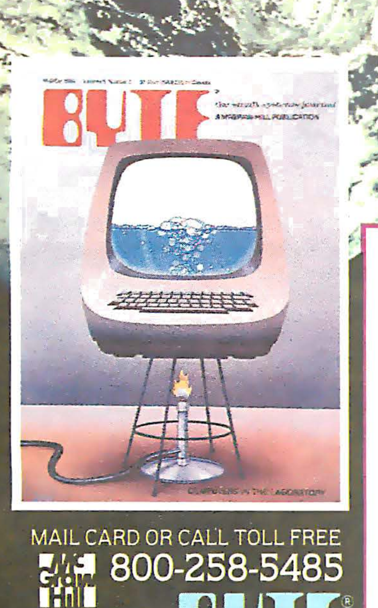
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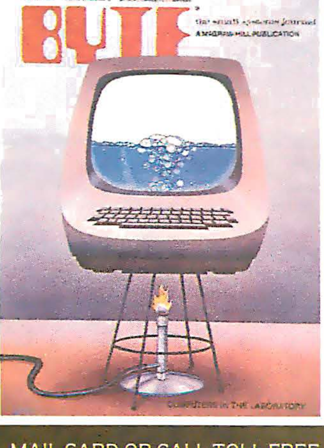
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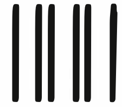
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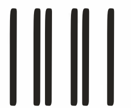
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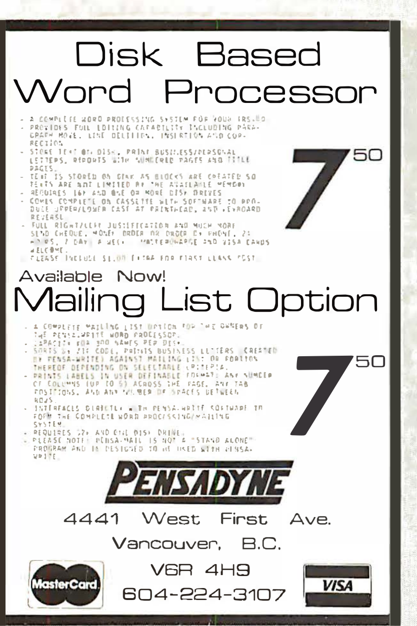
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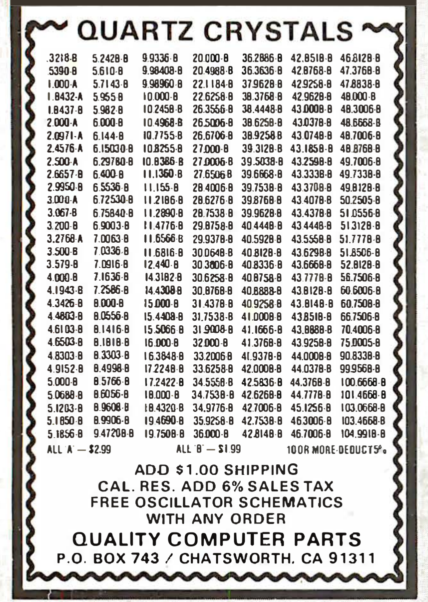
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.3218-B	5.2428-B	9.9336-B	20.000-B	36.2886-B	42.8518-B	46.8128-B
.5390-B	5.610-B	9.98408-B	20.4988-B	36.3636-B	42.8768-B	47.3768-B
1.000-A	5.7143-B	9.98960-B	22.1184-B	37.9628-B	42.9258-B	47.8838-B
1.8432-A	5.955-B	10.000-B	22.6258-B	38.3768-B	42.9628-B	48.000-B
1.8437-B	5.982-B	10.2458-B	26.3556-B	38.4448-B	43.0008-B	48.3006-B
2.000-A	6.000-B	10.4968-B	26.5006-B	38.6258-B	43.0378-B	48.6668-B
2.0971-A	6.144-B	10.7755-B	26.6706-B	38.9258-B	43.0748-B	48.7006-B
2.4576-A	6.15030-B	10.8255-B	27.000-B	39.3128-B	43.1858-B	48.8768-B
2.500-A	6.29780-B	10.8386-B	27.0006-B	39.5038-B	43.2598-B	49.7006-B
2.6657-B	6.400-B	11.1360-B	27.6506-B	39.6668-B	43.3338-B	49.7338-B
2.9950-B	6.5536-B	11.155-B	28.4006-B	39.7538-B	43.3708-B	49.8128-B
3.000-A	6.72530-B	11.2186-B	28.6276-B	39.8768-B	43.4078-B	50.2505-B
3.067-B	6.75840-B	11.2890-B	28.7538-B	39.9628-B	43.4378-B	51.0556-B
3.200-B	6.9003-B	11.4776-B	29.8758-B	40.4448-B	43.4448-B	51.3128-B
3.2768-A	7.0063-B	11.6566-B	29.9378-B	40.5928-B	43.5558-B	51.7778-B
3.500-B	7.0336-B	11.6816-B	30.0648-B	40.8128-B	43.6298-B	51.8506-B
3.579-B	7.0916-B	12.440-B	30.3806-B	40.8336-B	43.6668-B	52.8128-B
4.000-B	7.1636-B	14.3182-B	30.6258-B	40.8758-B	43.7778-B	56.7506-B
4.1943-B	7.2586-B	14.4308-B	30.8768-B	40.8888-B	43.8128-B	60.6006-B
4.3426-B	8.000-B	15.000-B	31.4378-B	40.9258-B	43.8148-B	60.7508-B
4.4803-B	8.0556-B	15.4408-B	31.7538-B	41.0008-B	43.8518-B	66.7506-B
4.6103-B	8.1416-B	15.5066-B	31.9008-B	41.1666-B	43.8888-B	70.4006-B
4.6503-B	8.1818-B	16.000-B	32.000-B	41.3768-B	43.9258-B	75.0005-B
4.8303-B	8.3303-B	16.3848-B	33.2006-B	41.9378-B	44.0008-B	90.8338-B
4.9152-B	8.4998-B	17.2248-B	33.6258-B	42.0008-B	44.0378-B	99.9568-B
5.000-B	8.5766-B	17.2422-B	34.5558-B	42.5836-B	44.3768-B	100.6668-B
5.0688-B	8.6056-B	18.000-B	34.7538-B	42.6268-B	44.7778-B	101.4668-B
5.1203-B	8.9608-B	18.4320-B	34.9776-B	42.7006-B	45.1256-B	103.0668-B
5.1850-B	8.9906-B	19.4690-B	35.9258-B	42.7538-B	46.3006-B	103.4668-B
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Foreword by **Arthur C. Guyton,** *University of Mississippi School of Medicine, Jackson*

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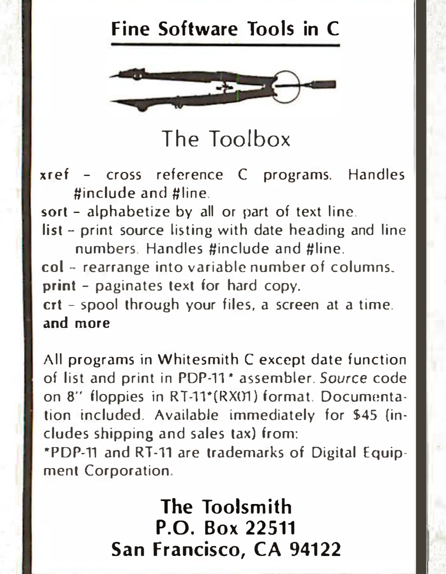
Feb. 1980, 250 pp., illus. Paper 06128 $14.50

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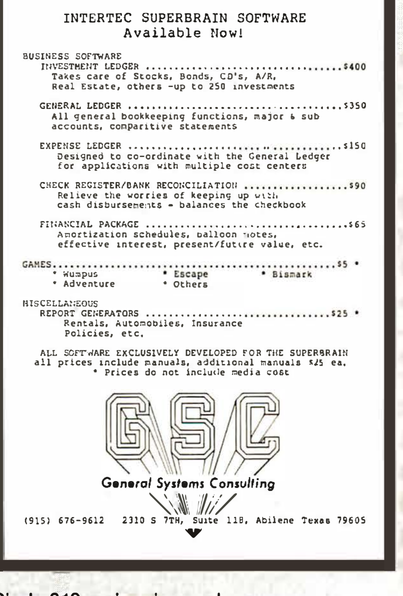
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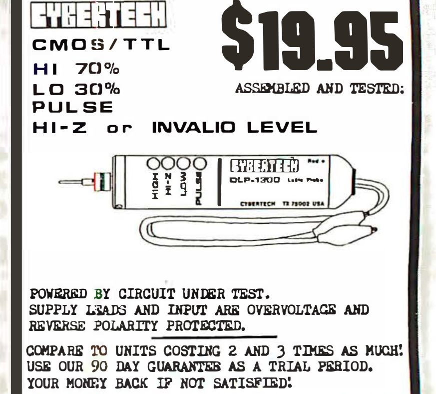
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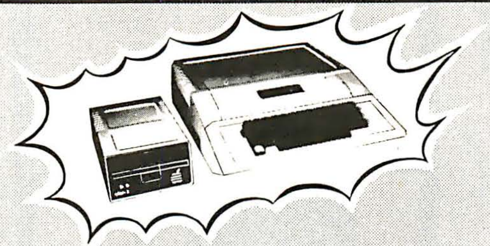
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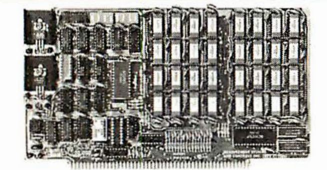






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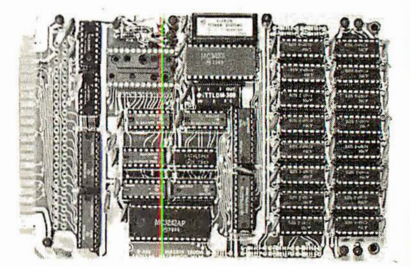
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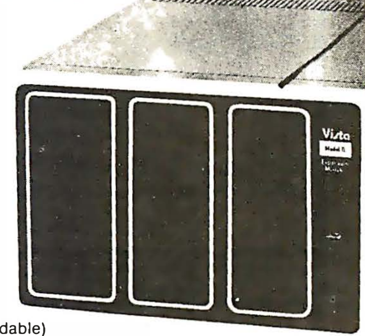




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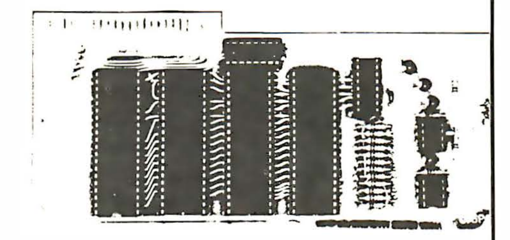
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4019	.45	4052	1.10	74C08	.30	74C173	1.30
4020	1.10	4053	1.10	74C10	.27	74C174	1.20
4021	1.10	4066	.70	74C14	1.20	74C175	1.20
4022	1.00	4069	.45	74C20	.27	74C192	1.30
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2.000 MHz, 6.144 MHz, 4.000 MHz, 8.000MHz, 3.000 MHz, 10.000 MHz, 3.57 MHz, 18.000 MHz, 5.000 MHz, 20.000 MHz, 6.000 MHz

RIBBON CABLE FLAT (COLOR CODED) #30 WIRE
16 cond. - .40/per foot
40 cond. - .75/per foot
50 cond. - .90/per foot

RS232 CONNECTORS
DB 25P male $3.25
DB 25S female ... $4.25
HOODS $1.50

200PRV 1A LASCR .95

LED READOUTS

FCS 8024 - 4 digit C.C. 8" display	$5.95	DL-707 C.A. .3"	$ .75
FND 503 C.C. .5"	$ .85	DL 747 C.A. .6"	$1.50
FND 510 C.A. .5"	$ .85	HP3400 .8" CA	$1.95
DL-704-.3" C.C.	$ .85	HP3405 .8" CC	$1.95

PRINTED CIRCUIT BOARD

4" x 6" DOUBLE SIDED EPOXY BOARD 1/16" thick $.60 ea .... 5/$2.60

EPOXY glass vector board 1/16" thick with 1/10" spacing 4½" x 6½" $1.95

74S00	.30	74S20	.40	74S153	1.10
74S02	.30	74S30	.40	74S151	1.25
74S05	.45	74S32	.40	74S157	1.25
74S08	.40	74S89	1.90	74S158	1.25
74S11	.35	74S112	.85	74S174	1.40
74S15	.40	74S140	1.00	74S257	1.50

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IL-5 OPTO-ISOLATOR .... $ .80
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100, 5K, 10K, 20K, 250K, $.75 each 3/2.00
SFC 3301 — 50PRV 30A FAST RECOVERY DIODE (35ns) $2.25

Silicon Power Rectifiers

PRV	1A	3A	12A	50A	125A	240A
100	.06	.14	.35	.90	.3.70	5.00
200	.07	.20	.40	1.30	4.25	6.50
400	.09	.25	.65	1.50	6.50	9.60
600	.11	.30	.80	2.00	8.50	12.50
800	.15	.35	1.00	2.50	10.50	16.50
1000	.20	.45	1.25	3.00	12.50	20.00

IN 4148 (IN914) .... 15/$1.00
.1 or .01 uf 25V ceramic disc. caps. 16/$1.00, 100/$50.00

REGULATORS

LM317T	$2.50	340K-12, 15 or 24V	$1.50
323K-5V 3A	$5.75	340T-5, 6, 8, 12, 15 18 or 24V	$1.10
79HGKC-5V at 5A	6.95	320M5	$ .75
723	$ .50	LAS1412 + 12V 3A	$3.95
320T-5, 12, or 15V	$1.10		
LM3056	$ .75		

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2N1307 PNP GE TO-5 .... $ .40
2N404A PNP GE TO-5 .... 3/$1.00
HEP G6014 — PNP GE TO-3 .... $ .85
TIP 121 — NPN Si SWITCHING .... $ .95
2N6233 NPN SWITCHING POWER $1.95
MRF-8004 a CB RF TRANSISTOR NPN .... $ .75
2N3772 NPN Si TO-3 .... $1.00
2N4908 PNP Si TO-3 .... $1.00
2N5086 PNP Si TO-92 .... 4/$1.00
2N3137 NPN Si RF .... $ .55
2N3919 NPN Si TO-3 RF $1.50
2N1420 NPN Si TO-5 .... 3/$1.00
2N3767 NPN Si TO-66 .... $ .70
2N2222 NPN Si TO-18 .... 5/$1.00
2N3055 NPN Si TO-3 .... $ .60
2N3904 NPN Si TO-92 .... 6/$1.00
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2N6109 PNP S, TO-220 .... $ .55
2N1309 PNP GE TO-5 .... $ .40
TIP 31B NPN Si TO-220 .... $ .60
TIP 32B PNP Si TO-220 .... $ .65

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7400	.17	7448	.75	74157	.65
74101	.17	7450	.17	74160	.85
7402	.17	7472	.35	74161	.80
7403	.17	7473	.35	74162	1.20
7404	.24	7474	.42	74163	.95
7405	.24	7475	.49	74164	.85
7406	.33	7476	.45	74165	.85
7407	.35	7480	.45	74166	1.05
7408	.27	7483	.60	74167	1.35
7409	.24	7485	.75	74170	1.60
7410	.17	7486	.42	74173	1.30
7411	.22	7489	1.60	74174	.85
7412	.22	7490	.50	74175	.75
7413	.42	7491	.55	74176	.75
7414	.90	7492	.50	74177	.75
7416	.33	7493	.50	74180	.75
7417	.37	7494	.60	74181	1.90
7420	.17	7495	.60	74190	1.20
7425	.35	7496	.60	74191	1.20
7426	.33	74107	.35	74192	.79
7427	.35	74121	.35	74193	.79
7430	.17	74122	.39	74194	.85
7432	.27	74123	.42	74195	.65
7437	.27	74125	.45	74196	.85
7438	.27	74126	.45	74197	.87
7440	.17	74145	.75	74279	.95
7441	.85	74150	1.10	74325	2.25
7442	.50	74151	.65	74365	.80
7445	.70	74153	.55	74367	.80
7446	.75	75154	1.10	74368	.65
7447	.75	74155	.75	75491	1.05
				75492	1.05
				8T98	1.10

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MTA 206 P-DPDT CENTR OFF $1.85
MSD 206 P-DPDT CENTER OFF LEVER SWITCH $1.85

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100			1.40
200	.80	1.30	2.20
400	1.00	1.65	3.30
600	1.30	1.90	4.40

DIP SOCKETS

8 PIN	.17	22 PIN	.30
14 PIN	.20	24 PIN	.35
16 PIN	.22	28 PIN	.40
18 PIN	.25	40 PIN	.60

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Si 1020 G 20 WATTS $13.75
Si 1050 G 50 WATTS $26.90

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.47UF 35 V	5/$1.00	6.8UF 35V	4/$1.00
.68UF 35 V	5/$1.00	15UF 16V	3/$1.00
1UF 35V	5/$1.00	30UF 6V	5/$1.00
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74LS00	.28	74LS153	1.19
74LS01	.29	74LS155	1.19
74LS02	.28	74LS156	1.19
74LS03	.28	74LS157	.85
74LS04	.35	74LS160	1.10
74LS05	.35	74LS161	1.10
74LS08	.35	74LS162	1.10
74LS09	.35	74LS163	1.20
74LS10	.30	74LS164	1.20
74LS11	.45	74LS168	1.25
74LS12	.35	74LS170	1.70
74LS13	.95	74LS173	1.30
74LS14	1.20	74LS174	1.00
74LS15	.35	74LS175	1.00
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74LS21	.55	74LS190	1.25
74LS22	.35	74LS191	1.15
74LS26	.35	74LS192	1.00
74LS27	.45	74LS193	1.10
74LS28	.45	74LS194	1.95
74LS30	.35	74LS195	1.10
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74LS37	.45	74LS197	1.10
74LS38	.55	74LS240	2.50
74LS40	.40	74LS241	2.95
74LS42	1.00	74LS242	3.00
74LS47	1.05	74LS243	2.75
74LS51	.35	74LS244	2.50
74LS54	.35	74LS251	1.29
74LS73	.60	74LS257	.90
74LS74	1.05	74LS258	1.50
74LS76	.45	74LS259	1.50
74LS85	1.10	74LS266	.70
74LS86	.45	74LS273	1.75
74LS90	.90	74LS279	.70
74LS92	.90	74LS290	.80
74LS93	.90	74LS293	.80
74LS112	.45	74LS365	.80
74LS113	.45	74LS366	.80
74LS114	.55	74LS367	.80
74LS125	.90	74LS368	.80
74LS126	.90	74LS375	.95
74LS132	.95	74LS377	2.75
74LS136	.80	74LS386	.50
74LS138	1.25		
74LS139	1.30		
74LS151	1.19		

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LM308 – .75
LM311 – .75
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LM386 – .80
LM387 – 1.25
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CA3086 – .95
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LM537 – 2.50
LM553 – 2.50
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565 – .95
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567 – 1.10
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703 – .85
709 – .25
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711CH – .40
741C or V – .30
747 – .50
LM1310 – 1.95
1458 – .50
3900 – .55
8038CC – 3.90
4136 – .95
LF356 – 1.25
NE540L – 2.50

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	1.5A	6A	35A	110A
100	.45	.60	1.40	
200	.70	.80	1.90	9.00
400	1.20	1.40	2.60	12.00
600		1.80	3.60	15.00

TRIACS

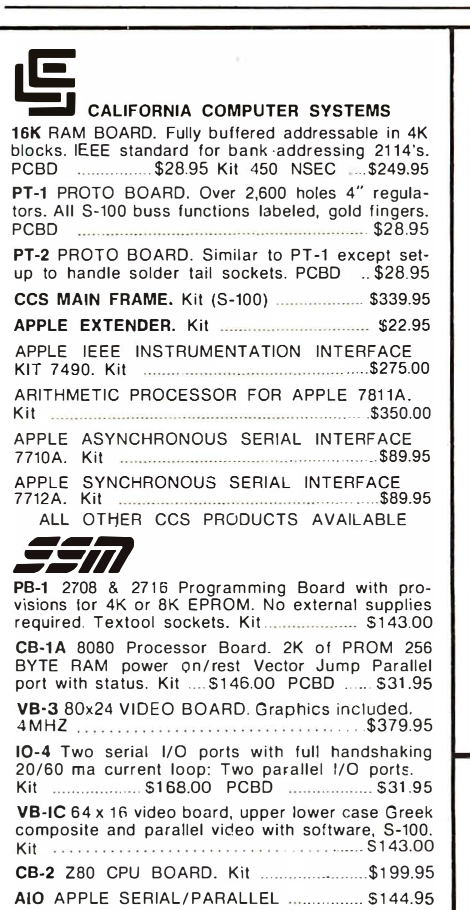
PRV	1A	10A	25A
100	.45	.80	1.55
200	.84	1.30	2.10
400	1.30	1.90	3.10
600	2.00	2.75	4.30

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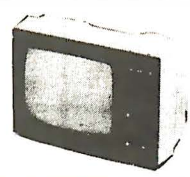
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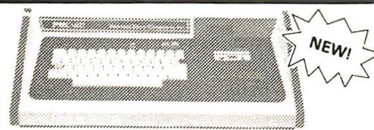
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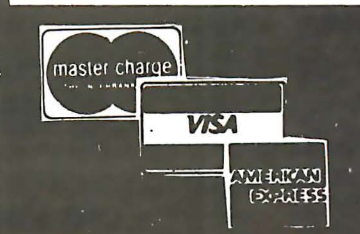
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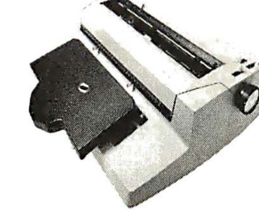
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4.0"	1.42	4.44	7.94	8.0"	2.14	7.38	13.73
4.5"	1.48	4.74	8.54	8.5"	2.18	7.69	14.36
5.0"	1.54	5.04	9.13	9.0"	2.24	8.11	15.01
5.5"	1.58	5.38	9.72	9.5"	2.30	8.32	15.65
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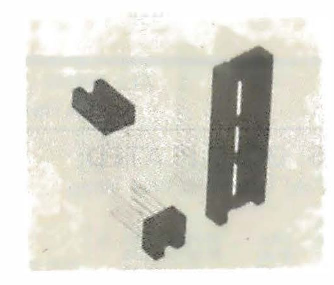
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15275	10/20 S/T	.140	2.00	1.85	1.60
15435	12/24 S/E PET	.140	2.60	2.35	2.10
15440	12/24 S/T PET	.140	2.65	2.40	2.15
15445	12/24 S/T PET	.200	2.75	2.50	2.20
15505	15/30 S/E GRI Key	.140	2.50	2.25	2.00
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15515	15/30 W/W GRI Key	.200	2.60	2.35	2.10
15600	18/36 S/E	.140	3.35	3.05	2.70
15610	18/36 S/T	.140	3.00	2.70	2.40
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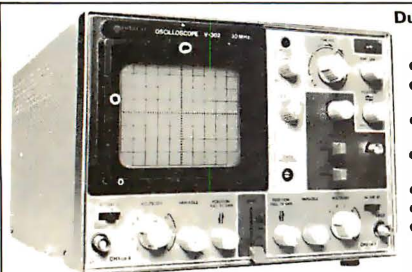
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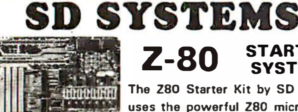
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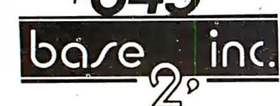
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74LS48	.78	74LS240	1.65
74LS51	.25	74LS241	1.65
74LS54	.35	74LS243	1.45
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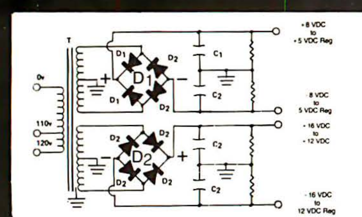
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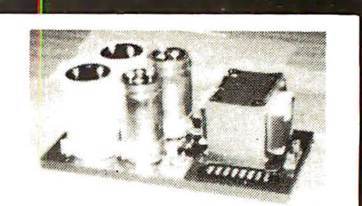
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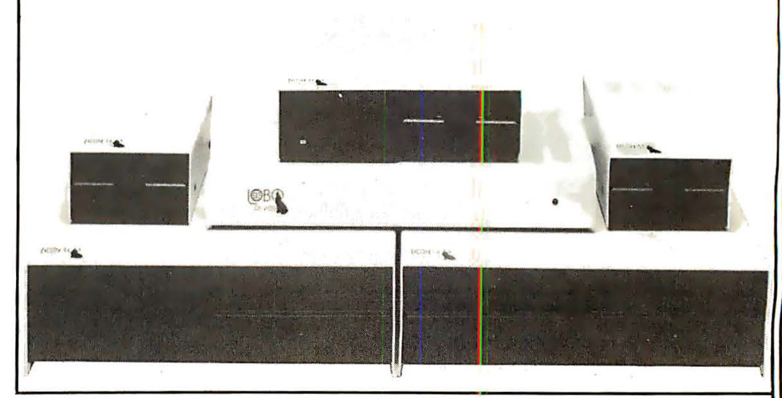
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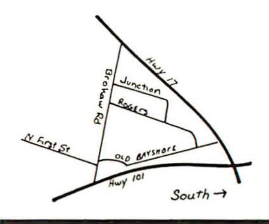
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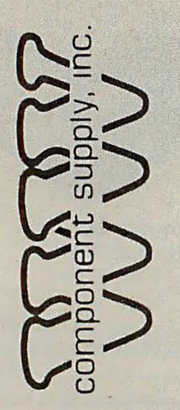
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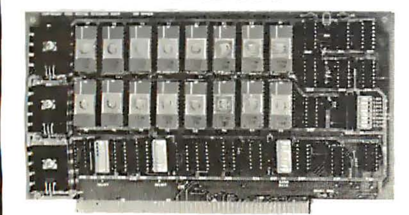
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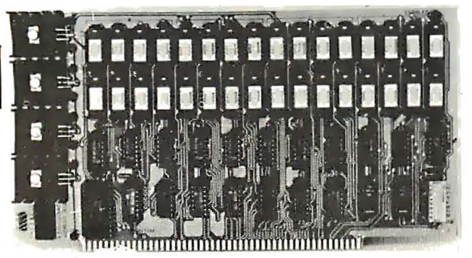
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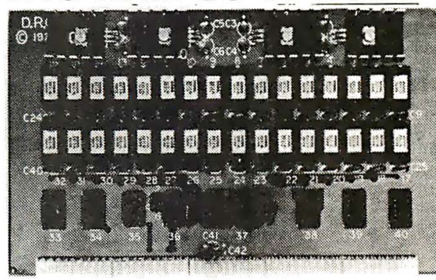
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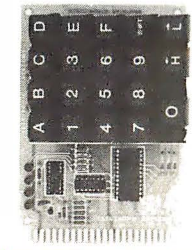
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Four onboard LEOs indicate the HEX code generated for each key depression. The board requires a single +5 volt supply. Board only $15.00 Part No. HEX-3, with parts $49.95 Part No. HEX- 3A. 44 pin edge connector $4.00 Part No. 44P.

ASCII TO CORRESPONDENCE CODE CONVERTER

This bidirectional board is a direct replacement for the board inside the Trendata 1000 terminal. The on board connector provides RS-232 serial in and out. Sold only as an assembled and tested unit for $249.95. Part No. TA 1000C

ASCII KEYBOARD

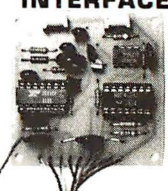
53 Keys popular ASR-33 format • Rugged G-10 P. C. Board • Tri-mode MOS encoding • Two-Key Rollover • MOS/DTL/TTL Compatible • Upper Case lockout • Data and Strobe inversion option • Three User Definable Keys • Low contact bounce • Selectable Parity • Custom Keycaps • George Risk Model 753. Requires +5, -12 volts. $59.95 Kit.

T.V. INTERFACE



● Converts video to AM modulated RF, Channels 2 or 3. So powerful almost no tuning is required. On board regulated power supply makes this extremely stable. Rated very highly in Doctor Dobbs' Journal. Recommended by Apple ● Power required is 12 volts AC C.T., or +5 volts DC ● Board only $7.60 part No. 107, with parts $13.50 Part No. 107A

TAPE INTERFACE



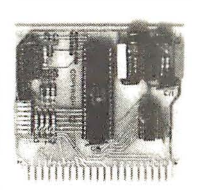
● Converts a low cost tape recorder to a digital recorder ● Works up to 1200 baud ● Digital in and out are TTL-serial ● Output of board connects to mic. in of recorder ● Earphone of recorder connects to input on board ● No coils ● Requires +5 volts, low power drain ● Board only $7.60 Part No. 111, with parts $29.95 Part No. 111A

T.V. TYPEWRITER



● Stand alone TVT ● 32 char/line, 16 lines, modifications for 64 char/line included ● Parallel ASCII (TTL) input ● Video output ● 1K on board memory ● Output for computer controlled curser ● Auto scroll ● Non-destructive curser ● Curser inputs: up, down, left, right, home, EOL, EOS ● Scroll up, down ● Requires +5 volts at 1.5 amps, and -12 volts at 30 mA ● All 7400, TTL chips ● Char. gen. 2513 ● Upper case only ● Board only $39.00 Part No. 106, with parts $145.00 Part No. 106A

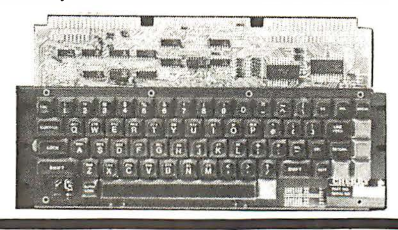
UART & BAUD RATE GENERATOR



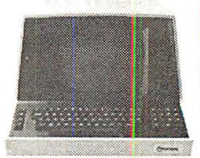
● Converts serial to parallel and parallel to serial ● Low cost on board baud rate generator ● Baud rates: 110, 150, 300, 600, 1200, and 2400 ● Low power drain +5 volts and -12 volts required ● TTL compatible ● All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity. ● All connections go to a 44 pin gold plated edge connector ● Board only $12.00 Part No. 101, with parts $35.00 Part No. 101A, 44 pin edge connector $4.00 Part No. 44P

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SOROC IQ 120



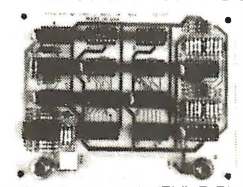
Upper/lower case display • Numeric keypad & cursor keys • Protected fields, ½ intensity display • RS 232 interface & aux. port. IQ120—$799.95 • IQ140 Detachable keyboard—$1199.95

MODEM



● Type 103 ● Full or half duplex ● Works up to 300 baud ● Originate or Answer ● Serial TTL input and output ● connect 8 Ω speaker and crystal mic. directly to board ● Requires +5 volts ● Board only $7.60 Part No. 109, with parts $29.95 Part No. 109A.

A-to-D D-to-A CONVERTER



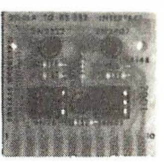
Analog to Digital, Digital to Analog Converter, A-D conversion time 20us. D-A conversion 5us. Uses include speech and music synthesizing and slow scan TV. Single power supply (5V), 8 Bits wide, latched I/O, strobe lines. Part No. 79287 Complete Kit $49.95 • Part No. 79287A Assembled $69.95

44 BUS MOTHER BOARD



Has provisions for ten 44 pin (.156) connectors, spaced 3/4 of an inch apart. Pin 20 is connected to X, and 22 is connected to Z for power and ground. All the other pins are connected in parallel. This board also has provisions for bypass capacitors. Board cost $15.00 Part No. 102. Connectors $3.00 each Part No. 44WP.

RS-232/20mA INTERFACE



This board has two passive, opto-isolated circuits. One converts RS-232 to 20mA, the other converts 20mA to RS-232. All connections go to a 10 pin edge connector. Requires +12 and -12 volts. Board only $9.95, part no. 7901, with parts $14.95 Part No. 7901A.

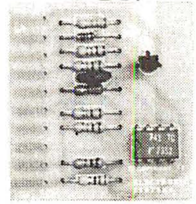
SOLID STATE SWITCH





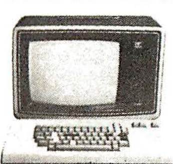
Your computer can control power (120VAC) to your printer, lights, and other 120VAC appliances up to 720 watts (6AMPS at 120VAC). Input 3 to 15 VDC, 2-13 MA TTL compatible, isolation 1500V. Part No. 79000K 1 Channel Kit $9.95 • Assm. $12.50 • Part No. 79004K 4 Channel Kit $34.95 • Assm. $44.95.

RS-32/TTL INTERFACE



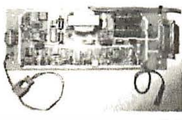
● Converts TTL to RS-232, and converts RS-232 to TTL ● Two separate circuits ● Requires -12 and +12 volts ● All connections go to a 10 pin edge connector, kit $9.95 Part No. 232A 10 Pin edge connector $3.00 part No. 10P.

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● Board supplies a regulated +5 volts at 3 amps., +12, -12, and -5 volts at 1 amp. ● Power required is 8 volts AC at 3 amps., and 24 volts AC C.T. at 1.5 amps. ● Board only $12.50 Part No. 6085, with parts excluding transformers $42.50 Part No. 6085A

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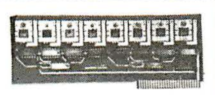
16K $975.95, Extra 16K E.S. RAM installed $74.95, extra 32K E.S. RAM installed $148.95.

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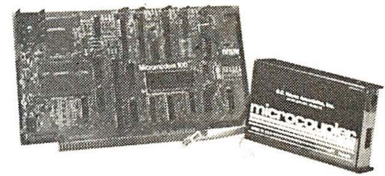
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This board has 8 triacs capable of switching 110 volt 6 amp loads (660 watts per channel) or a total of 5280 watts. Board only $15.00 Part No. 210, with parts $119.95 Part No. 210A

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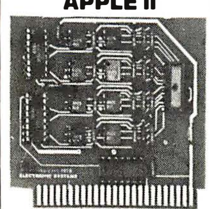


Fully S-100 bus compatible including 16-bit machines and 4 MHz processors. • Two software selectable Baud rates—300 Baud and a jumper selectable speed from 45 to 300 Baud. (110 standard). Supports originate and answer modes. • Direct-connect Microcoupler. This FCC-registered device provides direct access into your local telephone system, with none of the losses or distortions associated with acoustic couplers and without a telephone company supplied data access arrangement. • Auto-Answer/Auto-Call. The MICROMODEM 100 can automatically answer the phone and receive input; it can also dial a number automatically. • Automatic Reset and Disconnect. • Software compatible with the D.C. Hayes Associates 80-103A Data Communications Adapter. Micromodem-DCHA32625—$379.95

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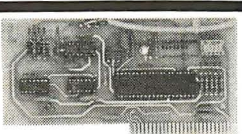
Part No. 7907 $14.95

OPTO-ISOLATED PARALLEL INPUT BOARD FOR APPLE II



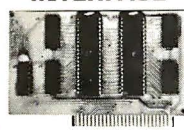
There are 8 inputs that can be driven from TTL logic or any 5 volt source. The circuit board can be plugged into any of the 8 sockets of your Apple II. It has a 16 pin socket for standard dip ribbon cable connection. Board only $15.00. Part No. 120, with parts $69.95. Part No. 120A.

APPLE II SERIAL I/O INTERFACE



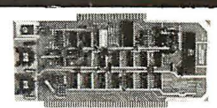
Baud rate is continuously adjustable from 0 to 30,000 • Plugs into any peripheral connector • Low current drain. RS-232 input and output • On board switch selectable 5 to 8 data bits, 1 or 2 stop bits, and parity or no parity either odd or even • Jumper selectable address • SOFTWARE • Input and Output routine from monitor or BASIC to teletype or other serial printer • Program for using an Apple II for a video or an intelligent terminal. Also can output in correspondence code to interface with some selectrics. • Also watches DTR • Board only $15.00 Part No. 2, with parts $42.00 Part No. 2A, assembled $62.00 Part No. 2C

APPLE II PARALLEL INTERFACE



Interfaces printers, synthesizers keyboards, and JBE A-D D-A Converter & Switches. This interface has 4 I/O ports with handshaking logic, 2-6522 VIA's and a 74LS74 for timing. Inputs and outputs are TTL compatible. Part No. 79295K Complete Kit—$69.95 • Part No. 79295A Assembled—$79.95

TIDMA

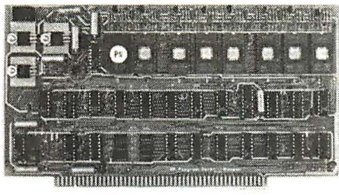


Tape Interface Direct Memory Access • Record and play programs without bootstrap loader (no prom) has FSK encoder/decoder for direct connections to low cost recorder at 1200 baud rate, and direct connections for inputs and outputs to a digital recorder at any baud rate • S-100 bus compatible • Board only $35.00 Part No. 112, with parts $110.00 Part No. 112A.

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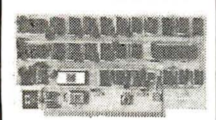
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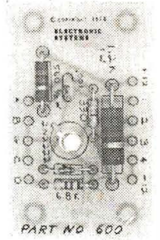


16 lines, 64 columns • Upper and lower case • 5x7 dot matrix • Serial RS-232 in and out with TTL parallel keyboard input • On board baud rate generator 75, 110, 150, 300, 600, & 1200 jumper selectable • Memory 1024 characters (7-21L02) • Video processor chip SFF96364 by Neculonic • Control characters (CR, LF, →, ←, ↑, ↓, non destructive cursor, CS, home, CL • White characters on black background or vice-versa • With the addition of a keyboard, video monitor or TV set with TV interface (part no. 107A) and power supply this is a complete stand alone terminal • also S-100 compatible • requires +16, & −16 VDC at 100mA, and 8VDC at 1A. Part No. 1000A $199.95 kit.

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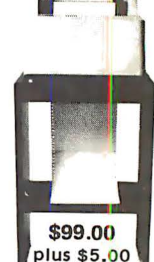
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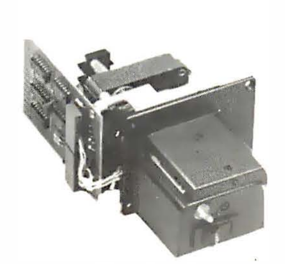
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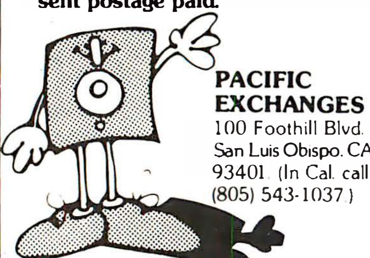


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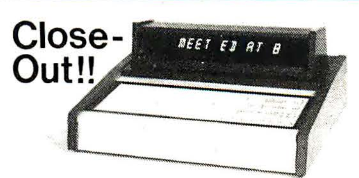
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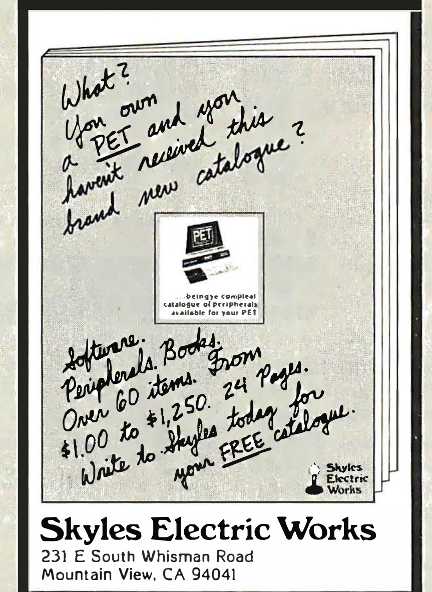
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12 slot S-100 mainframe with 20 amp power supply
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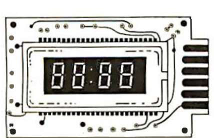
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National Semiconductor

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16K DYNAMIC RAM (150NS)
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- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 30 feet
- Simulated walnut case
- 115VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

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6-Digit Clock Kit



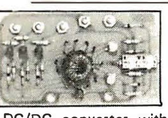
- Bright .300 ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
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- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

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DP8253	Prog. Interval Timer	14.95
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DP8259	Prog. Interrupt Control	14.95
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M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

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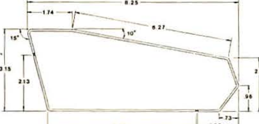
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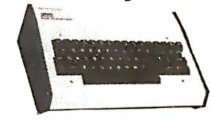
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Expand your 4K TRS-80 System to 16K.
Kit comes complete with:
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- Documentation for conversion

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DTE-AK $49.95
SPECIAL: JE610/DTE-AK PURCHASED TOGETHER (Value $129.90) $124.95

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FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD

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K19 (Keyboard only) $14.95

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40 characters per line
Speed: 40 characters per second
UL approved
High resolution dot matrix impact printer

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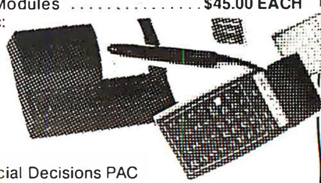
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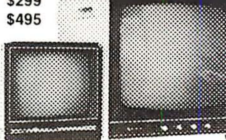
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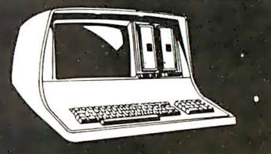
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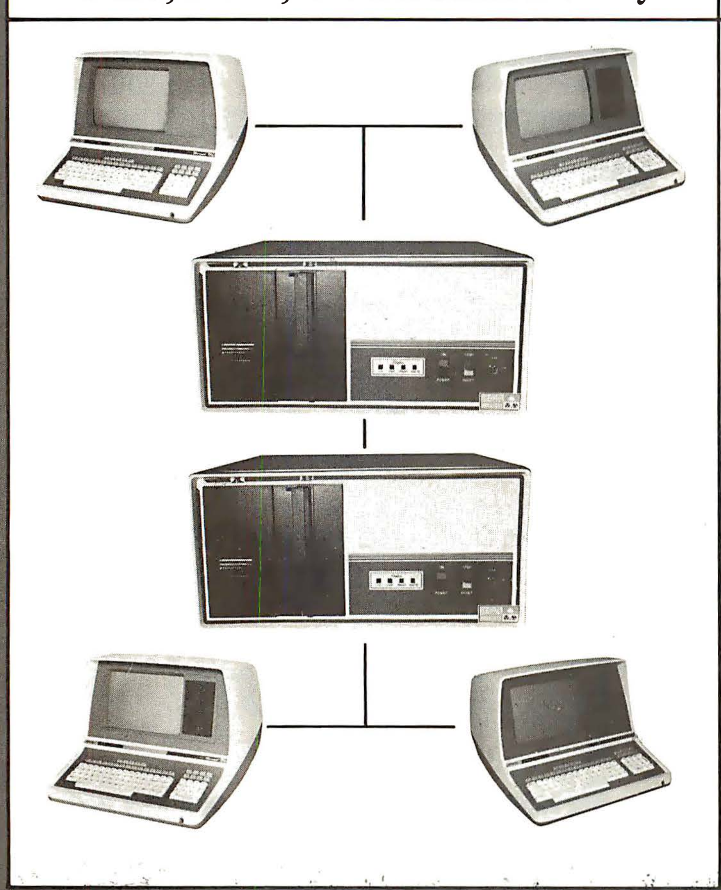


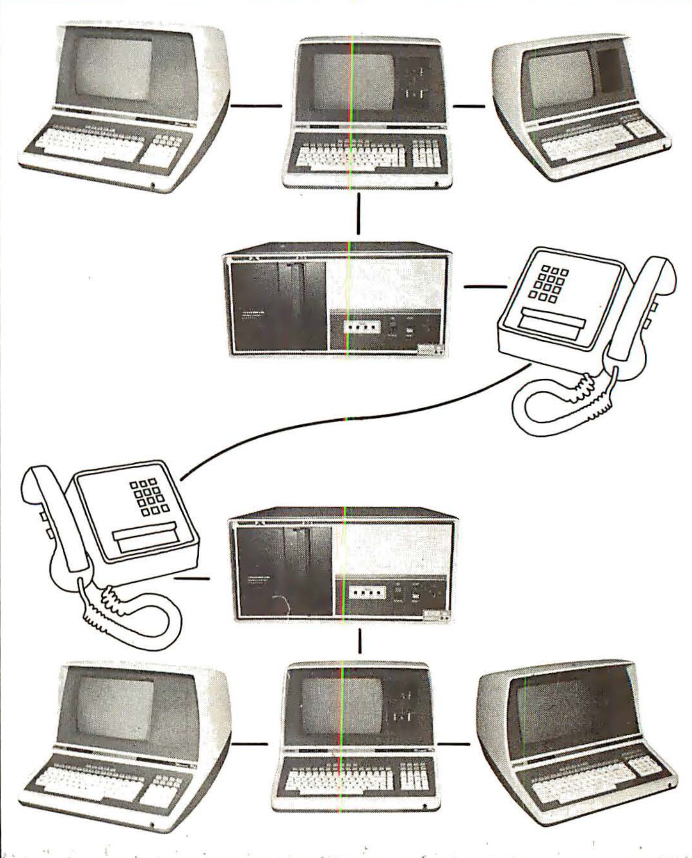
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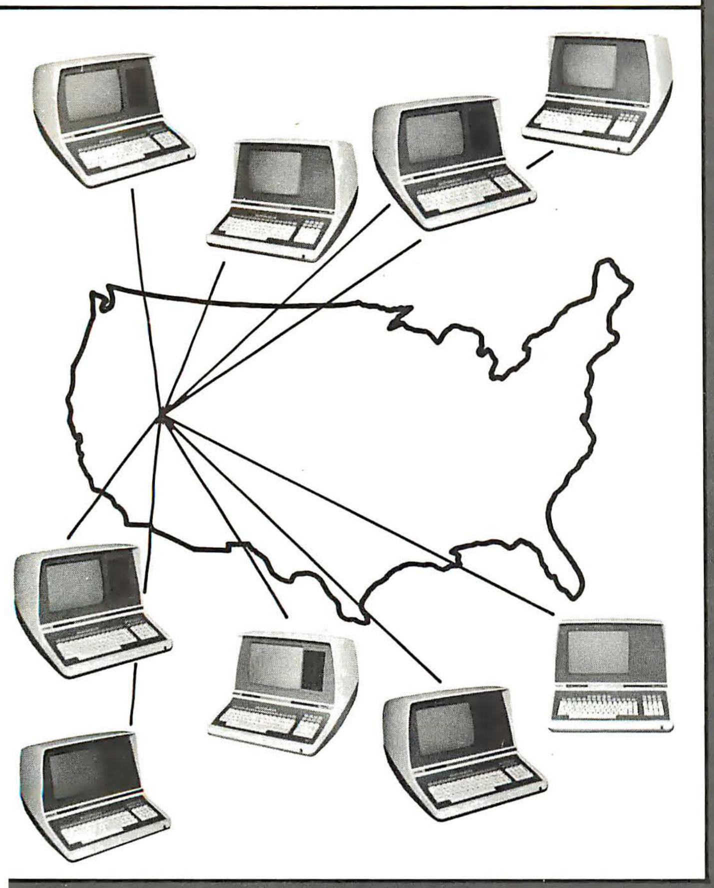
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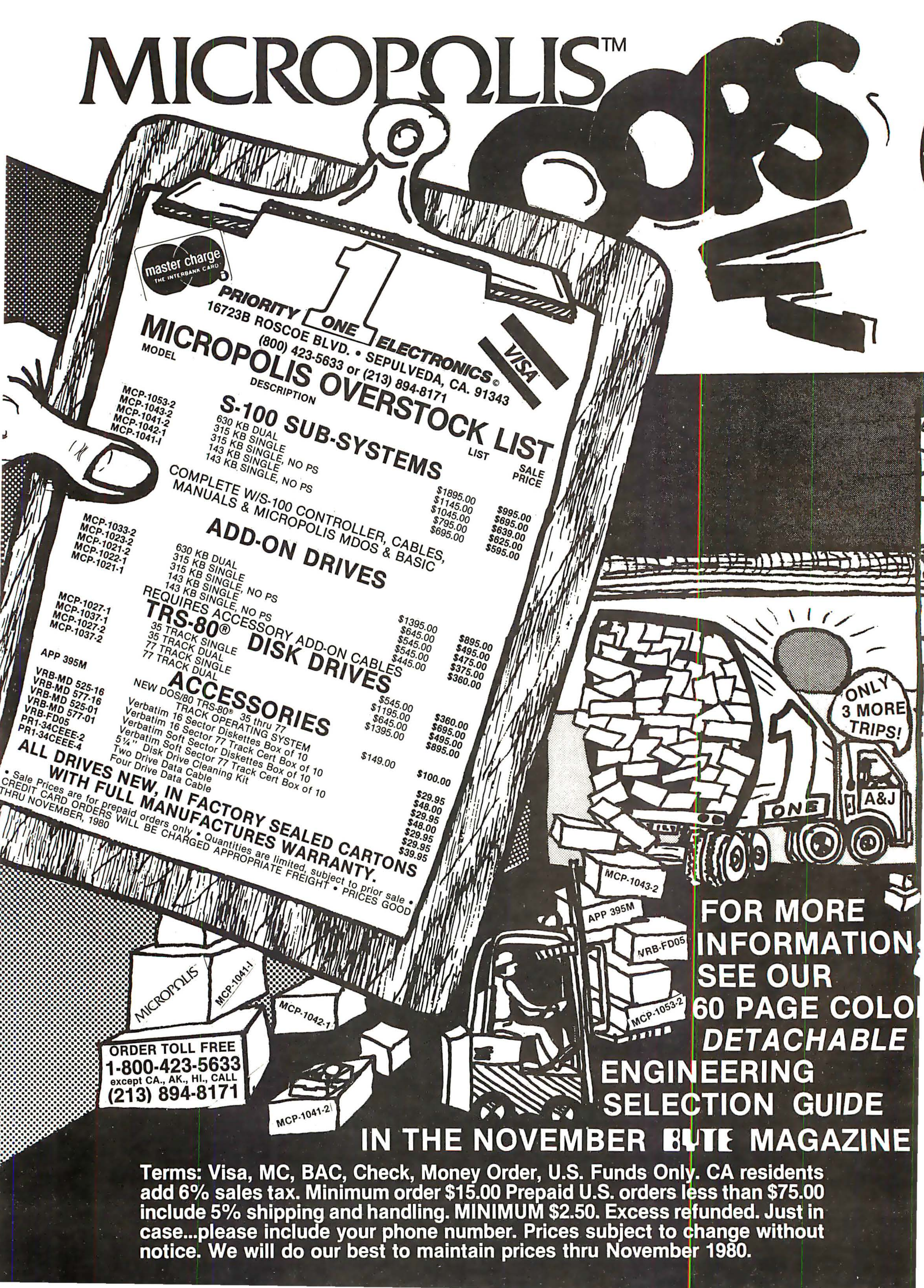
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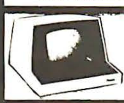
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8755 ...... 49.95
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5270	4.95		6605	7.95
5280	4.95		6604	4.95
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14	.19	.36	.59
16	.20	.36	.62
18	.24	.59	.84
20	.29	.69	.99
22	.24	.79	1.10
24	.36	.85	1.20
26	.43	1.10	1.49
36	.58	1.25	1.69
40	.60	1.40	1.89

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FND501	500	Red	Comm. Cathode (+1)	99
FND503(500)	500	Red	Comm. Cathode	99
FND507(510)	500	Red	Comm. Anode	99
FND508	500	Red	Comm. Anode (+1)	99
FND530	500	Green	Comm. Cathode	149
FND550	500	Orange	Comm. Cathode	149
FND803(800)	800	Red	Comm. Cathode	175
FND807(810)	800	Red	Comm. Anode	175
HP5082-7340	600	Red	4 x 7 Hexdecimal	2095
HP5082-7300	600	Red	4 x 7 Sgl. Digit RHD	18.95
HP5082-7731	300	Red	Comm. Anode	75
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TIL308	270	Red	Numerical Display	1095
TIL309	270	Red	Numerical Display	995
TIL311	270	Red	4 x 7 Hexdecimal	1095
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XAN3062	300	Red	Comm. Anode Left DP	125
XAN3063	300	Red	Overflow, CA, Left DP	125
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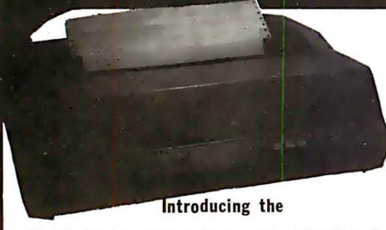
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DOT MATRIX PRINTER

Mfg. suggested list $1350

California Digital Introductory Price

$995

Full 136 Characters for the price of 80

DURABILITY...is the key component of the new Anacom 150. No bells, no whistles, no problems, just consistent high quality output.

This nine wire dot matrix printer features a ballistic type print mechanism guaranteed for three million characters. Low count (16) integrated circuits add to the reliability of the printer.

Microprocessor controlled logic seeking bi-directional head allows the Anacom to print up to speeds of 150 characters per second. 136 columns wide.

Adjustable tractors and variable head gap permit the Anacom to accept fifteen inch wide multi-part forms.

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Lexan paper shield and enclosure sound proofing add to the overall quality of the printer.

The Anacom 150 is definitely the best value in todays extremely competitive world of micro-printers.

If you are in the market for a "Quality Engineered" dot matrix printer, please consider the Anacom 150 before purchasing a less reliable machine.

Available either RS-232 serial 9600 baud. PRA-150S or Centronic parallel PRA-150P. Field exchange. UPS shipping weight 40 pounds.

IBM 3101 DISPLAY TERMINAL

The new 3101 display terminal is the IBM entry into the plug compatable micro computer industry.

This modularly constructed CRT terminal has been engineered with the user in mind. The video display modules swivels and tilts to provide the operator with a comfortable viewing posture.

Twelve inch P-39 green phosphor screen boasts a crisp 7 by 14 character matrix.

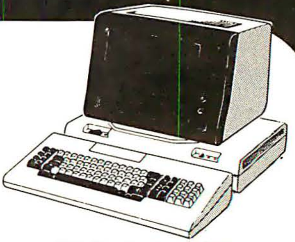
Standard 80 by 24 line screen format with a 25th line to display machine status and aid in the diagnostics in the event of a system malfunction.

87 key Selectric style keyboard arrangement along with numeric entry pad. Eight user definable function keys.

The 3101 video terminal is RS232 compatable and displays all 128 ASCII characters including control codes.

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But most of all, built into every 3101 terminal is the quality that you have learned to expect from the IBM Corporation. VDT-3101



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TEC V-300 Word Processing

Daisy Wheel Printer

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Finally a reasonably priced letter quality printer... Bi-directional printing at 25 characters per second. Full 136 print positions wide. Proportional spacing 1/120" horizontal, 1/48" vertical.
Uses standard Diablo brand interchangable daisy print wheels.
Intel 8085 CPU microprocessor controlled. Interfaces via Centronics parallel connector. Shipping 58 lbs. PRV-300.

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P-300

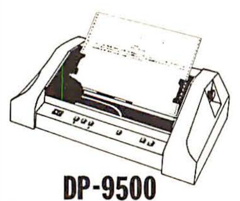
PRINTRONIX

$4500

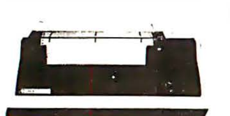
Forty-four separate print heads shuttle to provide overlapping dots. This unique feature allows a resolution of 60 dots per inch horizontal and 72 vertical.
The Printronix P-300 has the capability of outputing pictures, bar codes and large labels, a feature not provided with hand or chain printers. PRP-300 200 lbs.



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730 $595
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Both the Centronics 730 and the 737 are capable of accepting standard office letterhead or pin feed continuous forms.
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AMPEX DIALOGUE 80 CRT TERMINAL

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80 character by 24 line twelve inch screen. 18 key numeric-entry cluster. Reverse video. Displayable control characters. VDT-R25 ship. 60 lbs.

REGENT 30 $950
Additional features. Special function keys. High resolution graphics. 25th status line. Multi-intensity screen. Superior quality keyboard. VDT-R30

REGENT 40 $1195
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HEWLETT PACKARD

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APPLE II

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ATARI

800 $747
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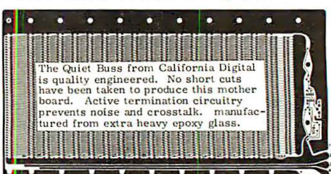
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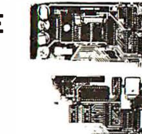
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D. C. HAYES PRODUCTS	
Micromodem for Apple	319
COMPUTER STOP PRODUCTS	
Double Vision / 80 Column Video	250
INTERACTIVE STRUCTURES	
16 Channel A/D card AIO/2	275
MOUNTAIN COMPUTER PRODUCTS	
Intro X-10 system for BSR	$239
Intro X-10 card only	165
16 channel AD/DA 8 bit	319
Apple Clock battery back-up	225
Supertalker SD200	245
ROM Plus with filter	165
ROM Writer/Programmer	149
APPLE BRAND PRODUCTS	
Apple Language card	450
Floppy disk with controller	560
Floppy disk without controller	495
Apple parallel interface	175
SSM MICROCOMPUTER	
Dual serial parallel interface AIO	149
SORRENTO VALLEY ASSOCIATES	
8" floppy controller (Pascal)	360

direct connect MODEM

UNIVERSAL DATA 103



Connects directly to the new modular phone jack. Fully powered from your existing telephone line. No need to locate external AC power. Crystal control prevents frequency drift. Direct connect feature eliminates loss of information due to carbon compression that is associated with acoustic modems.

$169



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NEW
from INTEGRAL DATA
460 Paper Tiger

**** All the features of the 440 and more ****

The 460 uses a dot matrix character formation technique in which the placement of the dots overlap both horizontally and vertically to achieve a correspondence-quality printing.
The printer's nine-wire print head uses staggered needle rows to create the vertically overlapping dots. The head is driven bi-directionally under microprocessor control by a stepper motor driven mechanism with logic-seeking look ahead capability.
Standard "Two-K Byte" buffer allows the printer to accept the entire content of a 1.920-character CRT screen. Weight 27 lbs.
suggested list price $1,295. Calif. Digital price **$1,076**

S-100 POWER SUPPLY
Mfg. for California Digital by SIERRACIN **$59**

Designed for on board regulation. 8V./8A.; ±16V./2A. Input:115/230VAC. 9x5x3" PWS-8A 4lbs.

Same as above but: 8V./20A; ±16V.4A. 11x5x4" PWS-20A $95

TELETYPE® MODEL 43



4320 KEYBOARD		
TTL ...... AAA	$ 950	
RS232 .... AAK	1050	plus shipping
Friction ... AAE	1100	
103 Modem AAB	1575	

WESTERN UNION ENCLOSURE

These enclosures were manufactured for Western Union by Universal Technology. The exact purpose of the product is still a mystery but the enclosure is ideally suited for an S-100 motherboard with shielded power supply. Removable hood and plexiglas front make this enclosure an attractive home for any hobby product. New surplus in factory boxes supplied with three 22/44 edge connectors; DB25S communications connector; six foot grounded power cord and more. Inside dimensions: 19" x 10 1/2" x 6 7/8." Shipping weight 8 lbs. **$24.95**

FREE
PLASTIC LIBRARY CASE with purchase of each box of .... Memorex mini-diskettes. $5 value.

$27 BOX of TEN

10 Boxes $24.95
100 Boxes $22.25
forty track

DISKETTES

DB25

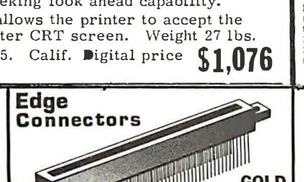
	each	10+
male	$2.50	2.25
female	3.25	3.05
hood-2p	1.25	.98
Centronic	6.95	

BCD Thumbwheel Switch 1.95



Ten Position
Mfg. by Digiswitch
1 7/8" high 1/2" wide

Edge Connectors



GOLD 100 PIN IMSAI/ALTAIR

Imsai solder .125x.250	$2.95	3/$ 7.50
Imsai w/w .125 centers	$4.95	3/$13.00
Altair soldertail .140 row	$5.95	3/$15.00
SPECIALS		
22/44 Kim eyelet .156"	$1.95	3/$5.00
25/50 solder tab .156"	$1.09	3/$2.00
36/72 wide post w/w.156	$1.95	3/$5.00

Lear Seigler Inc. In Plant POCKET INTERCOM $14.95

Another one of our mystery products. Manufactured by the Lear Seigler Company. The pocket intercom is supplied in a deep drawn blue anodized aluminium enclosure. Excellent for those special projects which require a touch of elegance. LSI list price $145. Supplied with chrome pocket clip. 9V transistor battery required. Model 1105. New surplus. measures 3.5 x 2.75 x 1.125" SPC-LSI

IEE Projection Module



$9.95 set of three **$25**

Voltage applied to one of the twelve discrete miniature incandescent #328 lamps causes the module to display the selected character. (+- Øthru 9). Users may substitute the character film and display pictures and symbols of their own choosing. Manufactured by Industrial Electronic engineers Inc. SPC-L 12 Used excellent cond. 24 lamp modules also avail.

Scotch® Data Products
Authorized Distributor



		10 Pak	50+
740-0	IBM soft format.	$39.00	$3.50
740/2	Double side soft	65.00	6.00
741-0	Double density	53.00	4.90
743-0	Double/Double	70.00	6.60
740-32	8" Hard sector	39.00	3.50
744-(0)(10)(16)	5 1/4" mini	39.00	3.50
Library case for any above;		Add $3.00	
834 A	Data Cassette	5.50	
DC 100	Mini Cartridge	16.00	
DC 300	Data Cartridge	20.00	
920( )	Disk Cartridge	89.00	

Shugart Associates
SA800-R Floppy Disk Drive





$449.50

XEROX 800 WORD PROCESSING KEYBOARD ASCII ENCODED



This 77 key word processing keyboard was manufactured by Microswitch for use in the Xerox 800 word processing system.
The keyboard outputs a seven bit ASCII code along with an eighth bit that allows most keys to shift and double function as special characters. Extra large "Tab & Return" keys are designed into the layout of the keyboard to emulate the IBM Selectric. 17 illuminated keys serve for special word processing codes. The keyboard is equipped with two thumbwheel switches for defining line width.
Original Xerox acquisition over $400.00
California Digital USED price only $49.00
Excellent cond. Documentation included.

MEMORY

TRS-80 APPLE II $39
16k memory (8) 4116's

Installation is simple. Anyone who has ever changed a spark plug should be able to up-grade his microcomputer.
How can California Digital offer these memory up-grade sets at 25% below our competition? Simple, we buy in volume, wholesale to dealers and sell the balance directly to owners of personal microsystems. These 16K dynamic memory circuits are factory prime and unconditionally guaranteed for one full year. NOW, before you change your mind, pick up the telephone and order your up-grade memory from California Digital. Add $3 for TRS80 jumpers.

STATIC	1-31	32-99	100-5C	-999	1K+
21L02 450nS.	1.19	.99	.95	.90	.85
21L02 250nS.	1.49	1.39	1.25	*	*
2114 1Kx4 450	5.95	5.50	5.25	4.75	4.50
2114 1Kx4 300	8.95	8.50	8.00	*	*
4044 4Kx1 450	5.95	5.50	5.25	*	*
4044 4Kx1 250	9.95	9.50	9.00	*	*
4045 1Kx4 450	8.95	8.50	8.00	*	*
4045 1Kx4 250	9.95	9.50	9.00	*	*
5257 low pow.	5.95	5.50	5.00	4.80	4.60

DATA INPUT TERMINAL
$49

This Keystation terminal was recently acquired from the CMC division of the Pertec Corporation. The unit was originally designed for inputing data directly onto magnetic tape.

The system is comprised of a premium cast aluminium and fiberglass enclosure, along with a Honeywell / Microswitch hall effect keyboard. Thirty display lamps advise the operator of the systems status. Four inch loud speaker acknowledges acceptance of data and alerts the operator of pending problems.

But most of all this "USED" terminal, with a little imagination, can be engineered to make the perfect home for an S-100 computer and video display; or with slight modification will accept the Rockwell AIM-65 micro/computer.

Five volt regulated power supply is available for an additional $20. (see June Byte) All units are in excellent condition. Original acquisition over $700. 22 lbs.

Scotch® DISKETTE HEAD CLEANING KIT



$24.95

Please specify:
8" or 5 1/4"

MINIATURE SWITCHES



your choice
$.98

SPDT Miniature Toggles

7101 C&K	ON-NONE-ON
7107 jbt	ON-OFF(mnt.ON)
7108 CK	ON-(moment ON)
7103 CK	ON OFF ON
Rotary	3P-4-Pos.
Rotary	3P-6-Pos.
Push B (N.O.)	$.39ea. 4/$1

DIP Switch



$1.29 ea.

10	25	100	1K
$1.19	1.09	.97	.83

specify 4 7 or 8 pos.
SPST

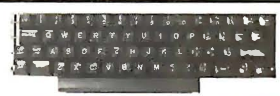
CONTROL DATA CRT Terminal?



$49

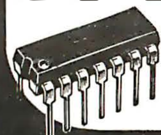
Frankly we made a mistake and are offering these terminals below our cost just to get them out of our warehouse. As far as we can determine the units are complete. But we are offering them on an "as-is" basis without any return privileges.
The terminals were originally purchased from All State Insurance.
At present we have been unable to secure any printed information on the units. If you have any doubts, please do not purchase one of these terminals. Shipped via truck. freight collect.

KEYBOARD $24.95



This classic Hytek keyboard is similar to the module used in the Decwriter Terminal.
62 non-encoded contacts three locking.
Factory boxed Altair surplus. Shipping 3 lbs.

2716 EPROM SALE $13



*** THOUSANDS ***
We have slashed price in an effort to reduce our over stocked inventory. These are Single Five Volt Eproms, manufactured by one of the Worlds largest producers of semiconductors. Please phone for volume pricing.

IBM 2980 SELECTRIC BANK TERMINAL $250

The IBM 2980 terminal was designed to be located at each tellers station in a branch bank. The terminal was on line to a master computer. Information entered into the terminal would instantaneously adjust the customers account at the computer. A record of the transaction would be entered into the customers passbook and simultaneously recorded onto a continuous 40 column paper roll located within the terminal.
The heart of the 2980 is the IBM Selectric typewriter. Each unit is supplied with print ball, ribbon and full documentation.
A potential use for this I/O terminal is in business applications where information must be entered onto ledger cards at the same time data is recorded at the computer. USED surplus, 77 lbs.

BSR SYSTEM X-10

The new BSR timer runs your home like clockwork. Turns on lamps and appliances while your away from home. Completely compatible with your existing system X-10 devices.





BSR Timer	$65.00
Master Console	34.95
Ultrasonic Controller	19.95
Modules: Appliance, Lamp or Wall Switch	13.95



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Circle 379 on inquiry card.

Computers, Disk Systems

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w/64K Double Density, List $3345 . . . . . $2883
w/64K Quad Density, List $3995 . . . . . . $3595
W/64K Quad — MiniMicroMart Upgrade Special. $3395

MICROMATION



A 64K complete computer with dual density 8" floppies (1 megabyte). Rack or vertical mounting. Systems with double-sided drives, hard disks, and multi-user (MP/M).

Z+ 100 64K RAM, Computer, $2495. . **$2099**
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"Z" system features new distributed processing multi-user concept with one Z-80 per user, with Z-80 for MP/M (Master Satellite concept).

AS LOW AS $11,899!

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RADIO SHACK TRS-80™

10% OFF!



INTERSYSTEMS
formerly ITHACA AUDIO



DPS-1, List $1795

Call for Price!

The new Series II CPU Board features a 4 MHz Z-80A CPU and a full-feature front panel. 20-slot actively terminated motherboard, with 25 amp power supply (50/60 Hz operation, incl. 68 cfm fan).

COMPLETE SYSTEM with InterSystem 64K RAM, I/O Board w/priority interrupt and double density disk controller board. Full 1-year warranty, List $3595

Call for Price!

HEWLETT-PACKARD
HP-85A

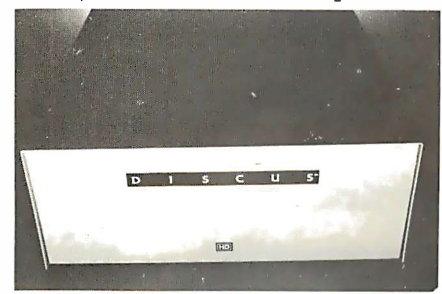
Desk-Top Computer

Call for Price

MORROW
THINKER TOYS® DISCUS M26™

26 megabytes of formatted storage
List $4,995

$4,199



THINKER TOYS® DISK SYSTEMS

Now includes CP/M® 2.2

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All Morrow systems now include CP/M® 2.2

NORTH STAR MDS-A
Double Density Mini Floppy Disk System

Double Density, Kit
List $799 **OUR PRICE $669**
Assembled and Tested. $719
Quad Version, Kit, List. $836
Assembled, List $1099. . . . . $896

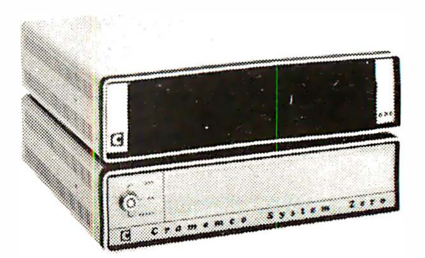
Above MDS-A units do not include cabinet or power supply.
Shipping and Insurance: Add $7.50.

NEW! CROMIX FROM CROMEMCO
A New UNIX Like Disk Operating System,
With true multi-user, multi-tasking capabilities

List $295 . . . . **OUR PRICE $249**

NEW! DOUBLE DENSITY CONTROLLER BOARD
FROM CROMEMCO
With built-in diagnostics

16 FDC Controller, List $595 **OUR PRICE $505**



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A complete 64K Computer with Double Density Disk Controller . . . . . . List **$2995**

OUR PRICE $2545

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Only **$3644** for a complete 64K Disk System

MORROW
Discus 2D's IN STOCK

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Upper and lower case, 15 baud rates: 75 to 19,000 baud, dual intensity, 24 x 80 character display, 12 x 10 resolution. Numeric pad. Programmable reversible video, auxiliary port, self-test mode, protect mode, block mode, tabbing, addressable cursor. Microprocessor controlled, programmable underline, line and character insert/delete. "C" version features typewriter-style keyboard. List $950

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920C (with 11 function keys, 6 edit keys and 2 transmission mode keys, List $1030

ONLY $849

Intertec EMULATOR

Software compatible with a Soroc IQ-120, Hazeltine 1500, ADM-3A or DEC VT-52. Features block mode transmission and printer port; 12" anti-glare screen; 18-key numeric keypad; full cursor control. List $895

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NEW INTERTUBE III

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12" display, 24 x 80 format, 18-key numeric keypad, 128 upper/lower case ASCII characters. Reverse video, blinking, complete cursor addressing and control. Special user-defined control function keys, protected and unprotected fields. Line insert/delete and character insert/delete editing, eleven special line drawing symbols.

SOROC



IQ-120
List $995
SPECIAL $729

IQ-140 List $1495
SPECIAL $1149

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1500 ONLY $879

1410 w/numeric keypad, List $900	$749
1420 w/lower case and numeric pad	849
1510, List $1395	1089
1520, List $1650	1389

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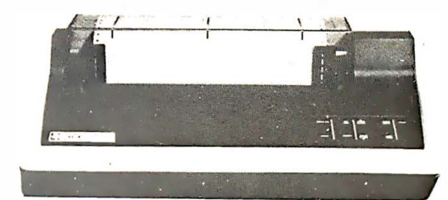


Terminal/Keyboard as well as RO Printer Only models available.
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NEW 737 parallel, friction, tractor	$849
779-2 w/tractor (same as TRS-80 Line Printer I), List $1350	1049
702 120 cps, bi-direct., tractor, VFU	1995
703 185 cps, bi-direct., tractor, VFU	2395
704 RS232 serial version of 703, $2350	$1995

TI-810



TI-810 Basic Unit, $1895	ONLY $1695
TI-810 w/full ASCII (Lower case), vertical forms control, and compressed print	$1895
TI-745 Complete printing terminal with acoustic coupler, List $1695	$1399

PAPER TIGER®





IDS-440 Paper Tiger, List $995	$895
w/graphics option, incl. buffer, $1194	$989
TRS-80 cable	45
NEW IDS PAPERTIGER 460 List $1295	$1149
NEW IDS PAPERTIGER 460G List $1394	$1199

NEW IDS 460
QUALITY PRINTING AT MATRIX SPEED—LOGIC SEEKING PROPORTIONAL SPACING
w/auto text justification

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Tractor Feed Option	$99
Serial interface	$89
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COMPRINT 912 w/parallel interf.	$559
912 w/serial interface, List $699	$589
MICROTEK, List $750	$675
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Above prices reflect a 2% cash discount (order prepaid prior to shipment). Add 2% to prices for credit card orders, C.O.D.'s, etc. Prices are f.o.b. shipping point. Prices are subject to change and offers subject to withdrawal without notice. **WRITE FOR FREE CATALOG.**

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Assembled and Tested
List $3095
ONLY $2619

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HORIZON 2, 32K, DD	$2619	48K, QD, List $4090	3469
32K, QD, List $3595	3049	64K, DD, List $3830	3239
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18 megabytes, plugs into parallel port of North Star Horizon. Utilizes tried-and-proven 14" Century Data Marksman. List $4999. **OUR PRICE $4199**

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Kit, List $669 .... ONLY $499

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***NEW* System 3**
by CROMEMCO
Now with Dua
Double Sidec
Double Density
(over 2 megabytes
of Storage
64K of RAM
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LIMITED TIME
INTRODUCTORY SPECIAL **$6199!**

CROMEMCO SYSTEM 2 — Now double Density with Double Sided Drives, Quad Capacity mini floppy disc drives. List $3990 .... **Only $3390**

CROMEMCO Z-2H Full 11-megabyte Hard Disk system. Fast Z-80A 4 MHz processor, two floppy disk drives, 64K RAM memory, RS232 special interface, printer interface, and extensive software available.
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From Cromemco
With built-in diagnostics — 16 FDC Controller
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NEW COLOR GRAPHICS INTERFACE — SOI List $595 **OUR PRICE $505**
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— WRITE FOR FREE CATALOG —

MiniMicroMart, Inc.

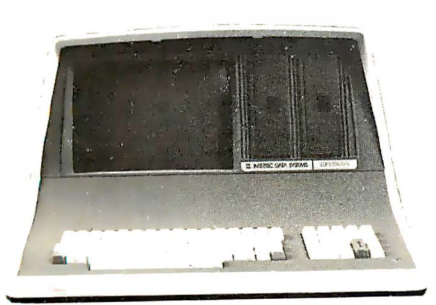
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Self-contained computer with dual disks and two RS232C ports. Complete with CP/M* 2.2 and BASIC.

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920C, List $1030 .... $ 849

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DP-9500, List $1650 .... $1399
DP-9501, List $1650 .... $1399
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w/graphics op., incl. buffer, $1195 ... $ 989
NEW IDS PAPERTIGER 460 . List 1295 $1149
NEW IDS PAPERTIGER 460G List $1394 $1199
NEC Spinwriters .... Call for Price
TELETYPE 43 KSR $1087
CENTRONICS
730-1 parallel interface .... *NEW LOW $679*
737 parallel interface .. *SUPER VALUE $849*
779 w/Tractor, List $1350 .... $1049
702 w/Tractor, VFU, List $2480 ...... $1995
703 w/Tractor, VFU, List $2975 ...... $2395
704 w/Tractor, VFU, List $2350 ...... $1995
TI 810 Basic, List $1895 .... $1695
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TI 820 KSR, List $2165 .... $1895
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912 w/serial interface, List $699 ...... $ 589
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MICROTEK, List $750 .... $ 675
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48K, Double Density, List $3590 ...... $3039
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FOR SALE: TRS-80 Model I Level 2, 48 K memory, expansion interface, two disk drives, Emako-20 matrix printer with Centronics cable. Sell all or part at 80% Radio Shack list price. Also diskettes, game cassettes, etc. Philip Crawford, 1720 E 1st St #10, Long Beach CA 90802, (213) 437-5475.

EDUCATORS: Small private school in central Connecticut (K-8) is considering implementation of microcomputers into curriculum. If you've previously experienced such an endeavor in this age group and would be willing to share an evening enlightening faculty and concerned parents, please contact us. We're eager to make this a successful program, and would be interested in learning how your program was launched and pitfalls to avoid. The Independent Day School, Laurel Brook Rd, Middlefield CT 06455, Attn: William Murdoch, (203) 238-3994.

FOR SALE: Voltage regulator, SOLA BASIC 750 VA Unit #63-13-175. Never used, output two outlets, 6.25 A maximum. $300, shipping additional. Jane Groene, 1 Harmony Ct, Syosset NY 11791, (516) 921-4900.

WANTED: KIM-1 or similar microcomputer for dedicated real-time system. Must be like KIM-1: easily expandable but otherwise a bare single-board system. Needed for temperature monitoring system in a solar greenhouse. Robert Heller, Star Route Box 51A, Wendell MA 01379, (617) 544-6416 between 8:30 and 5.

FOR SALE: Standard Memories Ecom memory system including Ecom memory core (32 K), heavy-duty power supply, all interconnecting cables, interface firmware card, and documentation. Original cost of $3500; will sell for $1000. All in excellent condition, both main units are for relay rack mounting. Steve Garber, 3030 Polk St, San Francisco CA 94109, (415) 474-7081.

FOR SALE: Eaton LRC 7000 plus 64-character printer; $250. Radio Shack Quick Printer II 32-character (Catalog #26-1155); $150. Send certified check or money order. William R Spencer Jr, 5421 Grandin Rd Ext, Salem VA 24153.

FOR SALE: LSI-11 processor (KD11-F) mounted in a four-slot backplane with a serial interface (DLV11), paper-tape operating-system package including PAL-11S Assembler, LINK-11S, ODT, PTSP, and single-user BASIC, with full documentation. Entire system never used, in mint condition. Original cost $1325, asking $1000. Also for sale, Processor Technology VDM-1, $100. M Wallin, 1607 Lauren Ct, Bensalem PA 19020.

FOR SALE: Hazeltine 1500 CRT terminal (less case, cable, XFMR); $450, Anderson Jacobson acoustic coupler #242A; $120, full ASCII keyboard; $50. S Gladstone, 150 W Cedar St #6, Norwalk CT 06854, (203) 866-8930.

WANTED: Soft black leather case for the HP-45, 65, or 67. New or used. E King, 870 W 181 St, New York NY 10033, (212) 568-3309.

FOR SALE: Ithaca Audio 8 K, 250 ns static programmable-memory board for S-100 with protect; $120. Ithaca Audio S-100 video-display board, 64-by-16 uppercase and lowercase with Greek symbols, normal or reverse video, 1 K on-board programmable memory; $75. Mostek 4115N dynamic-programmable memories; eight for $30. Ted Betz, Box 379A RD#1, Farmingdale NJ 07727, (201) 938-3722.

FOR SALE: DEC LSI-11 components: KD11-F processor board with FIS circuit and 4 K memory; DLV11 serial interface with remote data-rate switch. Also, Vadic two-speed modem: Bell 103/113 (300 bps) and 202 (1200 bps half-duplex) compatible. Sell both for half price. Bob Malahy, Mechanical Engineering Dept, Rice University, Houston TX 77001, (713) 664-8635 evenings.

FOR SALE: Color graphics board. Biotech CGS-808 with on-board microprocessor control for S-100 bus. Excellent condition, versatile, up to 256-by-192 resolution. Lots of software including 3D graphics. $362 postpaid. John Peterson, 1820 Camino Dr, Forest Grove OR 97116, (503) 357-6310.

FOR SALE: Apple II computer with 36 K memory, Applesoft Firmware Card, disk drive with controller, all manuals, plus extras. Everything is in excellent condition. $1200 or best offer. David J Bauman, 249 Taft St, Wind Gap PA 18091, (215) 863-5736.

WANTED: S-100 system: Z80 processor, 48 thru 64 K programmable memory, 15-slot mainframe, 5 V at 15 A, ± 18 V at 1 A power supply, video-display board, serial and parallel I/O. Optional: keyboard, cassette interface, and read-only memory monitor. Fred Tydeman, 3901 Northfield Rd, Austin TX 78759, (512) 255-9292 evenings.

FOR SALE: New PP 2708/16 eprom programmer by Oliver Audio Engineering, factory assembled; $200. Double-sided printed-circuit board plated through with schematic for building small system using Motorola MC14500 single-bit controller; $35 each. Charles Krasny, POB 57, Maple Falls WA 98266.

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These notices are free of charge and will be printed one time only on a space available basis. Notices can be accepted from individuals or bona fide computer users clubs only. We can engage in no correspondence on these and your confirmation of placement is appearance in an issue of BYTE.

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FOR SALE: SwTPC 6800 computer with 12 K memory, CT-64 with Motorola monitor, 2 serial and 1 parallel interface, AC-30 cassette interface, GT-6144 graphics board—all working. Cost over $1200; sell for $600. Also, OSI Challenger with 16 K, cassette interface, video board, extra boards. Cost over $1400; sell for $700. J Chirlgos, 4707 Larchmont NE, Albuquerque NM 87111, (505) 299-0378 after 5 PM.

FOR SALE: 64-word S-100 Model 50 Heuristics Speechlab; $50, Morrow Speakeasy S-100 1P, 1S, and cassette interface; $30, OAE paper-tape reader; $20. All work fine. Micro-Term ACT-1 terminal, as is; $30. Alex Begin, 7335 Deep Run, Birmingham MI 48010, (313) 642-7512.

WANTED: Three to six 8080 hackers to work with machine-language Monitor, Editor, and Assembler that I have developed. You will get free software in exchange for user comments and suggestions. First letter should give programming experience, computer type, and input format required. Robert G Durnal, POB 68, Junior WV 26275.

FOR SALE: Radio Shack 16 K Level II TRS-80 microcomputer. With numeric keypad, expansion interface, cassette recorder, and several game cassettes including *Microchess*. List price is $1200. I will sell for $750. First cashier's check/money order takes it (I pay shipping). Include SASE for confirmation. Chris Willson, 8726 S Sepulveda Apt 91B, Westchester CA 90045.

FOR SALE: Xitan Z80 system. Mainframe, ZPU, SMB, VDB, 48 K programmable memory, 16 K read-only memory (12 K BASIC in read-only memory), keyboard, manuals, software. Complete system $1600. Terry Young, 4 Aiken St, Derry NH 03038, (603) 434-0257.

FOR SALE OR SWAP: KSR-28 Teletype (not ASCII, uses 5-bit code) with manuals. $100 or will swap for an acoustic coupler, modem, or Radio Shack Voxbox. R L Reynolds, 30 Jordan St, Chelmsford MA 01863, (617) 251-8505.

NEEDED: Information, kit, schematics, or advice on turning ITEL word-processor typewriter Model 84101010 into computer terminal or printer. Gordon Dohle, 414-34 Kleisinger Cr, Regina Saskatchewan, S4R 7M4 Canada.

FOR SALE: IMSAI mainframe with 10-slot motherboard, Ithaca Audio Z80 processor board (with 2708), SSM VB1 video board, 32 K static-programmable memory, and Soroc 117-key professional keyboard. Best offer over $600. Bob Watson, (602) 526-2312.

WANTED: Student experimenter wants integrated circuits, transistors, capacitors, resistors, LEDs, books, catalogs, magazines, diodes, switches, tubes, wire, printed-circuit boards, knobs, TTL circuits, keyboards, crystals, transformers, and parts-identification book. Please state price and what you have to offer in full detail. Judy Stapleton, POB 536, Pine Lake GA 30072.

FOR SALE: IMSAI 8080 with 16 K bytes, 3 P plus S Teletype I/O board, Tarbell cassette interface, case, panel, and 22-slot motherboard. 8 K BASIC and all standard software. Panasonic cassette unit. Perfect condition. $600 plus shipping, or best offer. Also available: ASR33 teletypewriter. Dick Aronson, 61 Morton St, New York NY 10014, (212) 243-0623 home, (212) 758-6500 work.

WANTED: Clever machines and ideas do not always advance the state of the art, but they are fascinating! Do you have or know about any unusual computing devices (mechanical, electronic, analog, digital, unclassifiable)? I am seeking information about such things, historical or recent, completed or not—even just crazy, ingenious ideas. I am also buying unusual machines, books, manuals, and documentation, and am building models of some of the machines. Dick Rubinstein, 15 Maugus Ave, Wellesley Hills MA 02181.

FOR SALE: Radio Shack TRS-80 Model I Level II. Equipped with 36 K programmable memory, 10-key pad, expansion interface. Unit is barely used, has been factory serviced, and can handle additional 16 K programmable memory. $1000. Also, IBM Selectric Model 71-3 I/O device with TRS-80 printer-port interface. Gives letter-quality hard copy. $650. Take both for $1400. Doug Bowie, POB 3453, San Francisco CA 91449, (415) 861-6883.

FOR SALE: Diablo Hytype 1 Model 1200. Best of the daisy-wheel printers. Brand-new unit with in-feed friction platen and print wheel. Interface for Apple, TRS-80, and CP/M systems. Maintenance manual and additional interface information available. Scott Priester, 211 White Water Ct, Greer SC 29651, (803) 268-0678 after 6 PM.

FOR SALE: HP-41C calculator, card reader, two memory modules, and all manuals for $425. All components essentially new. The system was replaced by an HP-85 before all HP-41C components were received. Ernest W Graham, POB 396, Shaw Island WA 98286.

FOR SALE: Fairchild PEP 3870 development board. In circuit emulation of 3870 series single-chip microcomputers. Programs 38E70 and 2716 PROM. Never used. Paid $450; asking $350. Ron Sutherland, POB 1147, Lawrence KS 66044, (913) 841-9433.

FOR SALE: Expandor Black Box printer, 80-column, for connection to parallel port. Includes cable for connection to TRS-80 and maintenance manual with schematics. Cost over $350 two years ago. Needs some attention, but otherwise in good condition. $150 including UPS freight. Gary Taylor, Princeton Plasma Physics Laboratory, POB 451, Princeton NJ 08544, (609) 683-2573.

BOMB

BYTE's Ongoing Monitor Box

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FORTH Is First

John James' introductory article on FORTH won the BOMB first place in our fourth annual August language issue. Steve Ciarcia came in second with his construction article about a homemade modem for under $50. Kim Harris' unique article, "FORTH Extensibility," ran a close third. The BOMB cards for this month were unusually enthusiastic in their rating of individual articles, affirming the overall positive reaction to this issue. Several BOMB cards expressed support for the article on Khachiyan's algorithm. First place for August was 1.70 standard deviations above the mean, followed by second place at 0.95.■

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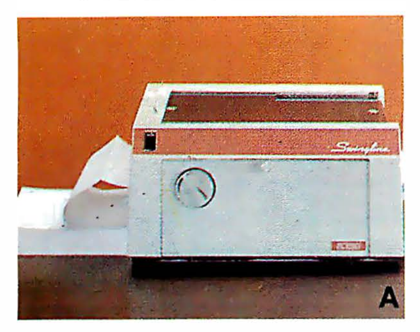
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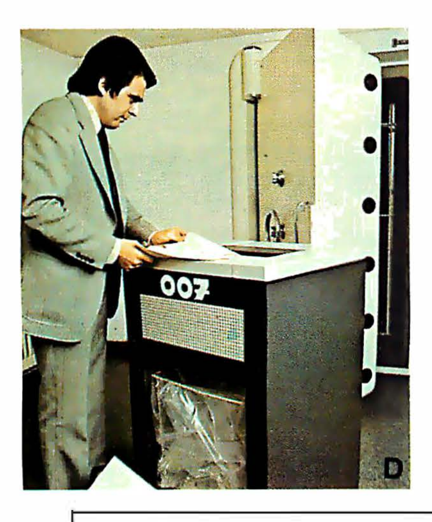


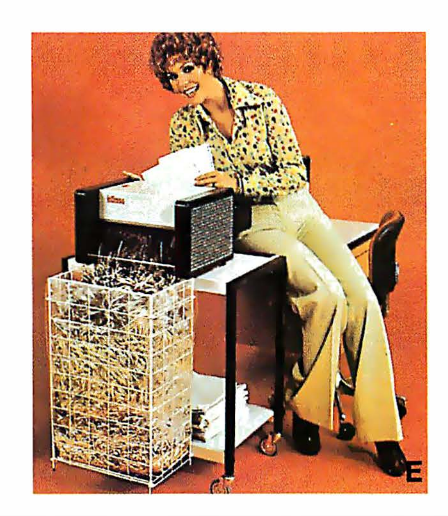
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B ☐ Our custom forms have a guarantee that speaks for itself. Our time on forms range from two to five weeks for custom work and before we start a job we now give a guaranteed shipping date and price, depending on art work, from two to five weeks and for every day we're late we give you a 10% discount. To get a quote just mail the detached portion of this ad with sample of form or layout and we will call you the day we get the information with a price and guaranteed day of shipment.

C ☐ The swingline table top decollator is a portable unit which separates both carbon and carbonless continuous computer forms into stacks. The separated carbon is easily and neatly removed from carbon pick-up spool. Form size is up to 15" wide. Wt. is 10 to 110 lb. bond paper, and the speed is variable from 75 to 200 feet per minute and takes only 120 volts AC 60 hertz to operate.

Wt. 40 lbs. **Price $ 419.00**

D ☐ The Datatech Intimus 007 shredder works for Scotland Yard, for government authorities, for important corporations, banks and embassies. The cutting capacity is 12 to 14 sheets at one pass. Cross cut is 1/35 x 3/8. It has a 2 H.P. motor and runs off of 220/380 V 3 phase.

Wt. 320 Lbs. **Price $6799.00**

E ☐ The Intimus 306 is designed for trouble free operation and has a switch for forward and reverse rotation. It has 2 motors with terminal overload. Housing consists of coated steel, mounted on rubber cushions for noiseless shredding. The 306 can sit on a table or a stand. Cutting width is ⅛" or ¼" and has two 150 watt 110 V 60 cycle, 1 phase motors.

Wt. 66 Lbs. **Price $1199.00**

F ☐ The Intimus Simplex is designed for security without problems in the office. One push of the button renders confidential information into five illegible paper strips ⅛" thin. The simplex has a wide opening in the middle for throw away of cans, etc. Even a paper clip is simply cut into pieces. The cutting capacity is 8 to 10 sheets at one time. It has a 1/5 H.P. motor and runs off of 110 volts.

Wt. 27 Lbs. **Price $ 599.00**

G ☐ Our catalog consists of more information on equipment in this ad. Other models are available plus a complete line of calculators and typewriters by Adler, Lathem time recorders, several varieties of safes, and our disintegrator that destroys paper, aluminum, film and carbon to a complete loss of identity.

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  74 millisec worst case access
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  Multiple operating systems on disk
  Ultra-high speed "FIND" command for high speed string searches (Associative Access)
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